IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Lamsfuss	)	Attorney Ref.: ZM337/03002
	)	Examiner: Elve, Maria Alexandria
Application No.: 10/813,452	)	Group Art Unit: 1793
Filed: March 30, 2004	)	Confirmation No.: 4667
For: Automatic Leveling Fixture	)	Date Submitted: January 2, 2009

Commissioner for Patents
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P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

AMENDED BRIEF ON APPEAL RESPONSIVE TO NOTICE OF NON-COMPLIANCE

This appeal brief is amended following the notice of non-compliance dated December 3, 2008. This is an appeal from the rejection of the Examiner dated January 24, 2008 rejecting Claims 1-13 and 25-36, all of the claims in the present case. The requisite fee for this appeal brief as set forth in 37 C.F.R. § 41.20(b)(2) was previously provided with the initial filing on September 23, 2008, and therefore is not included herewith.

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I. REAL PARTY IN INTEREST

The present application has been assigned to Hillerich & Bradsby Co., having a principal place of business at 800 West Main Street, Louisville, Kentucky, 40202. Hillerich & Bradsby Co. owns the exclusive right, title and interest in and to the present patent application and therefore is the real party in interest. An assignment to Hillerich & Bradsby Co. is recorded at reel number 015174 and frame number 0668 and has an effective recordation date of March 30, 2004.

II. RELATED APPEALS AND INTERFERENCES

Neither Applicant, Hillerich & Bradsby Co. nor their legal representative is aware of any related appeals or interferences which will directly affect or be directly affected by, or have any bearing on the Board's decision in the present appeal.

III. STATUS OF THE CLAIMS

The status of the claims currently pending is as follows:

Allowed claims: none

Claims Canceled: Claims 14-24

Claims objected to: none

Claims rejected: 1-13 and 25-36

IV. STATUS OF AMENDMENTS

Claims 1-13 and 25-36 are the subjects of the present appeal. No other claims are pending in the present application. The application was filed on March 30, 2004 with a restriction requirement mailed on December 6, 2005. Following election of the pending claims, the Examiner mailed a non-final rejection on March 27, 2006. In the subsequent response by Applicant, Claim 1 was amended and Claims 25-35 were added. A final rejection was mailed on October 17, 2006. Following an interview, Office Action Response C amended Claim 1 and added Claim 36. Subsequently on February 16, 2007, the Examiner removed the final rejection and mailed a non-final rejection. Applicant responded on April 2, 2007 wherein Claims 35 and 36 were amended substantively. On June 14, 2007, the Examiner mailed out a second final rejection. Applicant filed a request for a continued examination (RCE) on October 31, 2007 wherein Appellant amended Claims 1, 12, 25, 32, 33, 35 and 36 (Office Action Response E; October 31, 2007). Independent Claims 25 and 34 and the remaining dependant claims were not amended in that response. The Examiner mailed a non-final rejection on January 24, 2008. Following this rejection, during a brief telephone conversation, the Examiner suggested Applicant file an appeal. No claim amendments have been made following the pending rejection. Since these claims have been at least twice rejected, the case is ripe for appeal according to MPEP §1204 and under 37 CFR §41.31. Applicant filed a Notice of Appeal on June 23, 2008.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The present invention, as detailed in the specification and in the claims, is directed to an automatic leveling fixture which positions baseball bats of differing diameters for engraving by, for example, laser. The fixture consistently positions or "levels" the surface of baseball bats a distance from, or elevation relative to, an engraving laser regardless of the bat diameter, which differs based on the size of bat being engraved. See Application paragraph [0006] page 1, lines 16-20; see also paragraphs [0011] page 2, line 25-[0013] page 3, line 3.

By way of background, it is well known to engrave baseball bats, for example wooden bats, during manufacturing. It is also desirable to personalize engravings for such bats. See Application paragraph [0007] page 1, line 22-page 2, line 4. Since laser engravers must be at a consistent distance from the bat surface for proper focusing, it is important to position the bat at a preselected distance from laser engraver. See Application paragraph [0008] page 2, line 12. However, this is made difficult by the fact that baseball bats may vary in weight, length and therefore diameter. With a laser at a preselected position and a differing diameter for each of, for example, a first bat and a second bat, one skilled in the art will realize that the bat surfaces will be at different distances from the laser engraver. See Application paragraphs [0008-0009] page 2, lines 5-21. The present invention overcomes this problem by positioning a bat some preselected distance from the laser engraver, no matter what diameter baseball bat is being engraved. See Application paragraphs [0011] page 2, line 25-[0013] page 3, line 3.

Referring to the various Figures of the pending Application, the automatic leveling fixture [10] of **Claim 1** comprises a base [14] having at least one jaw slidably [20 or 22] connected to the base [14]. See Application paragraph [0025] page 4, line 21-page 5, line 3;

Figures 1-3 and 6-8. A base plate [16] is also vertically slidable relative to the base [14]. See Application paragraph [0033] page 8, lines 8-12. The at least one jaw [20 or 22] has an angled base plate camming surface [60] engaging the base plate [16] causing the at least one jaw [20 or 22] to move a preselected distance relative to a distance moved by the base plate [16]. See Application paragraph [0033] page 8, lines 4-12. When the jaws [20, 22] move some distance, the base plate [16] moves a corresponding distance. Alternatively stated, when the base plate [16] moves a distance, the jaws [20, 22] move some corresponding distance. See Application paragraphs [0033] page 8, lines 1-12 and [0035] page 8, line 30-page 9, line 20. The jaws [20, 22] are spring biased [58] causing the jaws to move inwardly and the base plate [16] to move up for a smaller diameter bat and oppositely for a larger diameter bat. Therefore the automatic leveling fixture [10] always compensates for lateral and vertical positioning no matter what diameter bat is to be engraved. See Figures 7 and 8. A bat [12] is also positively recited as an element of Claim 1.

Similarly, independent **Claim 25** also recites a first jaw [20] and a second jaw [22] biased toward the base plate [16] wherein each jaw has an inwardly directed base plate camming surface [60] directing the base plate [16] a preselected distance in relation to movement of the jaws [20, 22]. See Application paragraphs [0032] page 7, lines 25-[0033] page 8, line 12. A bat [12] is also claimed in combination with fixture of Claim 25. See Figure 1.

Independent **Claim 32**, in addition to the base [14], at least one jaw [20 or 22] and base plate [16] also recites an angled camming surface [60] operably engaging the base plate [16] and the at least one jaw [20 or 22] to retain bats of varying diameter at equal elevations regardless of

the bat diameter. See Application paragraph [0034] page 8, line 24; See Figures 7 and 8 also. A bat [12] is also a positively recited claim element.

Independent **Claim 33** recites a base [14], at least one jaw slidable [20 or 22] through a horizontal plane, a base plate [16] slidable through a vertical plane and an angled camming surface [60] extending between the at least one jaw [20 or 22] and the base plate [16] providing motion of the base plate [16] relative to the at least one jaw [20 or 22] and further wherein the base plate [16] is movable relative to the base [14], the at least one slidable jaw [20 or 22] and the angled camming surface [60]. See Application paragraphs [0025] page 4, line 21-page 5, line 6, [0033] page 8, lines 1-12, [0035] page 8, line 29-page 9, line 20 and Figures 7 and 8.

Claim 34 further recites a bat [12] in addition to a marking device [11] and further recites that the first and second jaw [20, 22] receive the bat [12] and the base plate [16] modifies the vertical position of the bat [12] to maintain an equal distance of the bat [12] to the marking device [11] regardless of the bat diameter. See Application paragraphs [0033] page 8, lines 1-12, [0035] page 8, line 29-page 9, line 20 and Figures 1, 7 and 8.

Claim 35 recites a fixture comprising a pair of slidable jaws [20, 22], a camming surface [60] engaging the pair of jaws [20, 22] and the base plate [16] and further that the base plate [16] is movable relative to the base [14], camming surface [60] and pair of jaws [20, 22]. See Application paragraphs [0033] page 9, line 1-12, [0035] page 8, line 29-page 9 line 20 and Figures 7 and 8.

Claim 36 recites a base plate camming surface [60] extending from the opposed jaws [20, 22] and engaging the base plate [16] causing the jaws [20, 22] to move a preselected distance relative to the distance moved by the base plate [16]. See Application paragraphs

[0032] page 7, lines 25-29, [0033] page 8, lines 1-12 and [0035] page 8, line 29-page 9, line 20 and Figures 7 and 8.

The dependent claims are argued to be allowable based on the dependence from allowable independent claims. In addition, specific dependent claims are argued specifically and support for those claims is provided herein. **Claim 6** recites a jaw channel [40] and is taught at paragraph [0028], page 6, lines 4-13. See also Figure 6. **Claim 11** recites a tapered receiving surface [72] and is taught at [0034], page 8, lines 19-24. See also Figure 4. **Claims 12 and 27** recite camming rollers [46] which are taught at paragraph [0030], page 7, lines 1-8. See also Figure 5. **Claim 26** recites guide posts [18] which are recited at paragraph [0029], page 6, lines 19-29. See also Figure 3 and 5. **Claim 28** recites tangential contact of the bat [12] and jaws [20,22] and base plate [16] at paragraph [0035], page 9, lines 9-11. **Claim 30** recites a ratio of slope in the camming surfaces [60] of two-to-one (2:1) at paragraph [0032], page 7, lines 25-29.

VI. GROUNDS OF REJECION TO BE REVIEWED ON APPEAL

A. Whether Claims 35-36 are improperly rejected under 35 U.S.C. §103(a) as being unpatentable over Sano *et al.* (U.S. Patent No. 6,705,372 – hereinafter "Sano").

B. Whether Claims 1-13 and 25-36 are improperly rejected under 35 U.S.C. §103(a) as being unpatentable over Sano and further in view of Comulada *et al.* (U.S. Patent No. 5,905,566 – hereinafter "Comulada").

C. Whether Claims 1-13 and 25-36 are improperly rejected over Sano in further view of Comulada and Baum (U.S. Patent No. 5,458,330).

The designations "A - C", above, correspond to the designations A - C in the Arguments Section VII, further herein.

VII. ARGUMENTS

For convenience, Appellant has attached in the Evidence Appendix as Exhibit A copies of the references relied upon by the Examiner in the pending rejection, dated January 24, 2008.

A. §103 Rejection of Claims 35-36 over Sano

The Examiner has rejected Claims 35-36 under 35 U.S.C. §103(a) as being unpatentable over Sano *et al.* (U.S. Patent No. 6,705,372). Appellant respectfully disagrees with the Examiner's allegations for the following reasons.

Regarding Claims 35 and 36, the Examiner's cited reference Sano (1) fails to provide every element of the pending claim and (2) the Examiner also fails to make a *prima facie* showing of obviousness for various other reasons.

1. A fundamental principle of patent law provides that "[t]o establish prima facie obviousness of a claimed invention, all claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F2d 981, 180 USPQ 580 (CCPA 1974). All words in a claim must be considered in judging the patentability of that claim against the prior art. *In re Wilson*, 424 F2d 1382, 1389, 165 USPQ 494, 496 (CCPA 1970)." See MPEP 2143.03 (emphasis added). Thus in order to have any expectation of rejecting the claims over a single reference or a combination of references, each limitation must be taught somewhere in the applied art. In this case, the applied prior art reference does not teach every limitation of the claims.

> **Claim 35** recites, in part:
>
> a camming surface engaging said pair of slidable jaws and a base plate, said base plate movable relative to a fixture base, said camming surface and said pair of jaws.

Sano fails to provide (a) a camming surface engaging the pair of slidable jaws [42] and a base plate [41a]. The Examiner apparently alleges that Sano element [42] is a camming surface – in the Response to Arguments Section of the January 24, 2008 Office Action, page 4. However, the only portions of elements [42] which could seemingly be considered camming surfaces are the horizontal "arms or extension" extending from the vertical portion of element [42]. Since the vertical portion or jaws [42] are positioned between, or separate, the extensions and the alleged base plate [41a], the horizontal arms or extensions do not engage both the slidable jaws [42] and the base plate [41a] as required by the claim.

Sano also fails to provide a **movable** base plate, as acknowledged by the Examiner at page 2, last full paragraph of the January 24, 2008 Office Action. Moreover, the non-existent **movable** base plate cannot also move relative to the fixture base, camming surface and pair of jaws, as required by the claim limitation. Therefore, the inter-relationship between the movable base plate, pair of jaws, camming surface and fixture base is not taught by Sano.

Claim 36 recites, in part:

> a base plate camming surface extending from said opposed jaws and engaging said base plate causing said jaws to move a preselected distance relative to a distance moved by said base plate.

Sano fails to provide a base plate camming surface extending from the opposed jaws [42] and engaging the base plate [41a], since the horizontal arms extending from jaws [42] away from base plate [41a] and therefore do not engage the alleged base plate [41a]. Sano also fails to provide a base plate which moves. The Examiner acknowledges such in her Office Action, page 2, last paragraph. Therefore, Sano also fails to provide a camming surface which

causes the jaws [42] to move a preselected distance relative to the distance moved by the base plate [41a].

2. In rejecting both of **Claims 35 and 36**, as well as the independent claims described further herein, the Examiner alleges that it would have been obvious to make the Sano base plate [41a] movable. Appellant respectfully disagrees and asserts that the Examiner has failed to make a *prima facie* showing of obviousness for the following reasons: (a) Sano teaches away from the claimed invention; (b) the Examiner's proposed modification would render Sano inoperable for its intended use; (c) there is no teaching or suggestion for the modification proposed by the Examiner, apart from the Appellant's disclosure; and therefore (d) the Examiner has made a hindsight rejection.

a) It is a well-established principle of law that a *prima facie* case of obviousness may not properly be based on a reference which teaches away from the present invention as recited in the claims.

"A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by applicant. *In re Sponnoble*, 160 USPQ 237, 244 (CCPA 1969). As "a useful general rule … a reference that 'teaches away' cannot create a prima facie case of obviousness." In re Gurley, 31 USPQ2d 1130, 1132 (Fed. Cir. 1994). "[W]hen the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious." *KSR International Co. v. Teleflex Inc.*, 550 U.S. ___, ; 127 S.Ct. 1727, 1741 (2007), citing *U.S. v. Adams*, 383 U.S. 39 (1966).

Sano teaches away from the claimed invention. Sano teaches a "**fixed** clamp" [11] which is contrary to the proposed movement alleged by the Examiner at Col. 5, lines 52-58; see also Col. 6, lines 46-58. A **fixed** clamp body [13] is configured with the **fixed** clamp [11]. See Col. 6, lines 46-47. The tube guide [40] is shown in Figure 7 of Sano having bolt holes at lateral ends of the body [41] which **fix** the tube guide [40] in a specific position. "A tube guide 40 for accurately setting the tubes is fixed to the body cover 14 of the fixed clamp 11." Col. 7, lines 40-41. Clearly, Sano teaches these fixed elements in the apparatus base which provide for accurate positioning of the tubes being joined.

To the contrary, the Examiner alleges element [41a] to be the claimed base plate, and further alleges it would be obvious to make this base plate [41a] movable. However, the alleged base plate [41a] is fixed with the other portion of the tube guide [40] in the fixed clamp [11]. Such fixed portion of the clamp provides a seat for the tubes, as taught by Sano. Were this not a fixed base [41a] then the tubes might become separated during the process taught. Appellant asserts that Sano teaches away from the suggested vertical movement of the base plate or movement of the base plate relative to the jaws and base as alleged by the Examiner.

Sano also teaches away from the claimed invention because of the use of the movable clamp [12]. The movable clamp [12] is positioned over the tubes being joined. The movable clamp [12] is locked in position in holding the tubes in position during the joining process. See Figures 1 and 9. See also Col. 5, lines 52-58; Col. 7, lines 61-67; Col 14, lines 58-62. "In case the movable clamps 12, 82 are erroneously opened, this would release clamp in of the tubes 7, 8 and thus tubes cannot be held anymore." Col. 15, 23-25. In other words, the movable clamp 12 must be closed for operation. However, using such clamp over the top half of a baseball bat, as

in the present invention, would inhibit laser engraving, shown in Figure 1 of Appellant's application. The movable clamp [12] would preclude access to the barrel of the baseball bat and therefore the bat could not be engraved.

b) Appellant also asserts that the Examiner's alleged movement of base plate 41a would render the Sano device inoperable. As cited above, the tube guide [40] is fixed to the fixed clamp [11] to accurately set the tubes. See Col. 7, lines 40-41. Making the base plate [41a] movable in a vertical orientation as alleged by the Examiner would remove the accuracy in the vertical dimension that Sano requires. Sano teaches "a warped groove 41a is formed in the center of guide base 41 on which the tubes are set." Col. 7, lines 49-50; see Figure 7. If alleged base plate [41a] were movable vertically as alleged, consistent contact between the tubes being joined would not be achievable. This is especially true since the upper portion of the tube connecting apparatus, movable clamp [12], moves down against the fixed clamp [11] to effectuate engagement of the tubes (see Figure 9). If the alleged base plate [41a] moved downward, the tubes could not engage properly for clamping and joining. Simply put, the device would be inoperable.

Additionally, opening the upper movable clamp [12] of Sano in order to engrave a bat a as taught by Appellant would render the Sano device inoperable, since the movable clamp [12] must be closed for operation.

c) The Appellant's invention is also asserted to be non-obvious for the following reasoning. Although the Court rejected a rigid application, the teaching, suggestion, motivation (TSM) test may still be used as one factor in a comprehensive flexible, common-sensical obviousness analysis. ("In the years since the Court of Customs and Patent Appeals set

forth the essence of the TSM test, the Court of Appeals no doubt has applied the test in accord with these principles in many cases. There is no necessary inconsistency between the idea underlying the TSM test and the *Graham* analysis.") *KSR International Co. v. Teleflex Inc.* 127 S.Ct. 1727, 1741 (2007); See also *KSR* quoting *Dystar v. C.H. Patrick Co.*, 464 F.3d 1356, 1367 (2006) ("Our suggestion is in actuality quite flexible and not only permits, but requires, consideration of common knowledge and common-sense.") In this instance, Appellant respectfully asserts that Sano fails to provide any reasonable teaching, suggestion or motivation for the inter-relationship of claimed movement between the movable jaws, movable base plate and camming surface because of the fixed base components taught by Sano. Moreover, where the Examiner alleges an alternative motivation in page two of the January 24, 2008 office action, Appellant respectfully reminds the Board that the lower portion of the Sano connecting apparatus to which the Examiner refers, is taught as a "fixed clamp" [11]. Although the Examiner alleges that part of this fixed device could be movable, the Examiner's proposed change to the Sano tube connecting apparatus would render the device inoperable because a moveable base plate would not provide a fixed seat for the tubes being joined as required by Sano.

d) Based on the various missing elements, inoperability of the proposed modifications, and the lack of teaching, suggestion or motivation in the cited art, Appellant can only presume that the Examiner has made a hindsight rejection. *KSR* describes that "a patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art." *KSR International Co. v. Teleflex Inc.*, 550 U.S. ___, ; 127 S.Ct. 1727, 1741. "This is so because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be

combinations of what, in some sense, is already known." Id. In making an obviousness rejection, an Examiner should not simply pick and chose elements from the prior art. "One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." In re Fine, 5 USPQ2d 1596, 1600 (Fed Cir 1988). The Supreme Court warned against "distortion caused by hindsight bias" and cautioned against "arguments reliant upon *ex post* reasoning." See *KSR* citing *Graham*, 383 U.S. 1, at 36 (warning against a "temptation to read into the prior art teaching of the invention in issue" and instructing courts to "guard against slipping into the use of hindsight." (quoting *Monroe Auto Equipment Co. v. Heckethorn Mfg. & Supply Co.*, 332 F. 2d 406, 412 (CA6 1964))).

Sano teaches a device for connecting tubes. Although the Sano device performs a clamping function, the Examiner alleges modifications which would render the Sano device inoperable, as previously described. Additionally, Appellant respectfully submits that the due to the movable clamp [12] of Sano which must be positioned over the top of a workpiece, one skilled in the art could not utilize the Sano device for engraving. Appellant asserts that, in combination with the Sano device, a workpiece, for example a baseball bat, would be covered by the moveable clamp [12] and therefore would not be engravable in that area of the bat. Where the Examiner's art teaches away from the proposed modification, where the cited art functions in a way which would inhibit the engraving taught by the Appellant, and where the cited art fails to teach or suggest the claimed invention, it becomes clear that the Examiner has picked and chosen known elements of the prior art based on the Appellant's teachings to render this rejection.

B. 35 U.S.C. § 103 Rejection of Claims 1-13 and 25-36 over Sano in view of Comulada

The Examiner has rejected Claims 1-13 and 25-36 as being obvious over Sano in view of Comulada. Appellant respectfully disagrees with the Examiner's allegations for the following reasons.

Appellant addresses the independent Claims 1, 25 and 32-36, as they are believed to be allowable and would render the dependent claims allowable as well. Specific discussion of the dependent claims follows argument of all independent claims. Appellant incorporates the arguments of Section VII (A) in this discussion.

Appellant first describes the various **missing elements** of the independent claims.

1. With regard to **Claim 1**:

a) Sano fails to teach or suggest a "base plate being slidable relative to said base." The Examiner acknowledges that the base plate [41a] of Sano is not movable in her rejection of Claims 35-36.

b) Sano also fails to provide the inter-relationship of jaw movement a preselected distance relative to a distance moved by said base plate. Specifically, Sano fails to teach or suggest the "base plate camming surface engaging said base plate causing said at least one jaw to move a preselected distance relative to a distance moved by said base plate." Instead, Sano only teaches moveable "jaws" [42], which do not move relative to a distance moved by the base plate [41a]. This is due to the fact that Sano's base plate [41a] does not move because it is part of the **fixed** clamp [11].

c) Further, Sano also fails to teach or suggest "a bat engaging said at least one jaw and said base plate when said leveling fixture moves said bat to a preselected position." The element, "a bat" is positively recited in the claim and therefore is a claim element. However, the Examiner does not address the bat element, and only makes a vague statement regarding intended use without respect to any specific claim limitation. Appellant asserts that Sano in view of Comulada fails to teach the bat element or engagement thereof, by at least one jaw and base plate.

d) Comulada fails to aid the lack of the above teachings. The Examiner alleges that Comulada discloses the laser ablation of a substrate which uses a chuck with a leveling device. Appellant has described to the Examiner previously that the term "leveling", used in Appellant's claim preambles, means that the baseball bat is moved to a specific level, i.e. position or elevation. See, for example, Office Action Response C page 7, lines 11-16 and Application paragraph [0024], line 18. The term "leveling" as currently used does not mean level, in the sense of flat or balanced. However, the Examiner insists that Comulada uses a chuck "with a leveling device," at page two of her January 24, 2008 Office Action. Comulada teaches a leveling device which "levels" by rendering a substrate flat. Specifically, a "top surface of the substrate and the lower surface of the reference chuck are in parallel planes when the chuck is placed on the working surface of the leveling device." See Comulada Abstract. More specifically, Comulada fails to teach a slidable base plate, the inter-relationship of movement of jaws and base plate, or a bat which is moved to a preselected position. For these reasons, the cited combination fails to render Appellant's invention of Claim 1 obvious.

2. With regard to **Claim 25**:

a) Sano fails to teach or suggest, "an inwardly directed base plate camming surface," as recited. Instead the only camming surfaces (horizontal arms or extensions) shown in Figure 7 of Sano extend away or outwardly from the alleged base plate [41a].

b) Sano also fails to provide a base plate camming surface which is "directing said base plate a preselected distance in relation to movement of said jaws." As previously described, the alleged base plate [41a] is not movable, but is instead a part of the **fixed** clamp [11].

c) Sano also fails to teach a bat as previously indicated. The "bat" is a positively recited element of Claim 25 and is not taught or otherwise suggested by the prior art references Sano or Comulada.

d) Comulada fails to aid the lack of teaching or suggestion of Sano.

3. With regard to **Claim 32**:

a) Sano again fails to teach the inter-relationship of structural movement which is currently claimed. Specifically, Sano fails to teach or suggest, "at least one base plate moving relative to movement of said at least one jaw by an angled camming surface operably engaging said base plate and said at least one jaw." As previously described, Sano fails to meet this limitation because of the failure to provide a movable base plate. Instead, the alleged Sano base plate [41a] is fixed as it is part of the fixed clamp [11].

b) Sano also fails to provide a bat, which is a positively recited element of the claim.

c) Sano also fails to meet the limitation "wherein said fixture retains bats of varying diameter at equal elevations regardless of the bat diameter." Since Sano fails to teach or suggest a bat, Sano also fails to teach or suggest a fixture that retains bats of varying diameter at equal elevations regardless of bat diameter. This is due to the fact that the alleged base plate [41a] does not move, as required by the claim.

d) Comulada does not aid these failures to teach or suggest the claimed elements.

4. With regard to **Claim 33**:

a) Sano fails to provide "a base plate slidable through a vertical plane a distance relative to said sliding of said at least one jaw". The alleged base plate [41a] does not move, as previously indicated, but instead is fixed in place. See Sano, Figure 7.

b) Sano fails to teach or suggest the angled camming surface which provides "motion of the base plate relative to said base and said at least one slidable jaw and wherein said base plate is movable relative to the base, said at least one slidable jaw and said angled camming surface." Again, the Sano reference fails to teach or suggest the claimed inter-relationship of movement of the base plate relative to the base, jaws and fixture base.

c) Comulada does not aid these failures to teach or suggest the claimed elements.

5. With regard to **Claim 34**:

a) Sano fails to teach a base plate, "in contact with a bat". Similarly, Sano fails to teach or suggest jaws in contact with "opposite sides of said bat." As previously

indicated, there is no teaching or suggestion of a bat by Sano. Instead Sano teaches connection of flexible tubing.

b) Sano also fails to teach or suggest jaws which receive the bat and "cause said base plate to modify the vertical position of said bat to maintain an equal distance of said bat to said marking device regardless of said bat diameter." This failure is due to the fact that Sano fails to teach or suggest a movable base plate. The alleged base plate [41a] is not movable but instead is fixed within the fixed clamp [11]. Movement of base plate [41a] would render the apparatus inoperable, as previously discussed.

c) Comulada does not aid these failures to teach or suggest the claim elements.

6. With regard to **Claim 35**:

a. Sano fails to teach or suggest "said base plate movable relative to said fixture base, said camming surface and said pair of jaws." To reiterate, the Sano base plate [41a] (Figure 7) is not movable and therefore cannot move relative to the alleged fixture base [41], the alleged camming surface [42] and the alleged pair of jaws [42]. The Examiner acknowledges such in her initial rejection of Claim 35.

7. With regard to **Claim 36**:

a. Sano fails to teach or suggest a "base plate being slidable relative to said base and said opposed jaws."

b. Sano also fails to teach or suggest "a base plate camming surface extending from said opposed jaws and engaging said base plate causing said jaws to move a preselected distance relative to a distance moved by said base plate." Sano provides for

movement of the alleged jaws [42] but no movement of the alleged jaws [42] **relative to a distance moved by the alleged base plate [41a].** Again, this is because the alleged base plate [41a] does not move.

8. In reference to all of the independent claims, Appellant further asserts that the Sano reference, in combination with Comulada, fails to render Appellants claimed invention obvious for the following reasons, which are described more in depth with respect to the rejections of Claims 35 and 36, are incorporated herein and therefore are only briefly reiterated. Sano teaches away from the claimed invention where the claimed base plate is movable and Sano teaches the alleged fixed base plate (central groove) [41a] as part of a fixed clamp [40]. The Appellants further assert that the Examiner's proposed modifications would render the Sano device inoperable. Sano teaches a fixed base plate [41a] for positioning of tubes to be joined. A vertically movable base, as proposed by the Examiner would result in a device which does not allow for proper clamping and joining of tubes. Additionally, a clamp over the top portion of the bat, as taught by Sano movable clamp [12] would inhibit engraving sought by Appellant. However, removal of the movable clamp [12] to allow engraving, taught by Appellant, would render the Sano device inoperable. Further, the Examiner's cited reference Sano fails to provide suggestion or motivation for (a) the inter-relationship of claimed movement between the movable jaws, movable base plate and camming surface or (b) the relationship of base plate movement distance to the jaw movement distance. The Sano reference teaches a fixed "base plate" [41a] not a moveable base plate. Comulada does nothing to aid this lack of teaching or suggestion. Finally, the failures of the Examiner's rejections make clear that the Examiner has

rejected the claims using the Appellant's teachings, rather than considering how one of ordinary skill in the art would solve the problems in the area of baseball bat engraving.

9. **Dependent Claims 2-13 and 26-31**

Appellants assert that Claims 2-13 and 26-31 are allowable based on the reasoning previously provided and those arguments are hereby incorporated. In addition, **Claim 3** should be allowed since the cited art fails to provide, and the Examiner fails to point out, any relationship between the jaws movement and base plate movement. Regarding **Claim 6**, the cited art fails to provide, and the Examiner fails to point out, the claimed rail element. Regarding **Claim 11**, the cited art fails to provide the claimed tapered receiving surface. Regarding **Claim 12**, the cited art fails to provide the claimed notch and rollers. Regarding **Claim 26**, the cited art fails to provide, and the Examiner fails to point out, the claimed guide posts on the alleged base plate. Regarding **Claim 27**, the cited art fails to provide, and the Examiner fails to point out, the claimed camming rollers. Regarding **Claims 28**, the cited art fails to provide, and the Examiner fails to point out, the claimed tangential contact with the bat in the fixture. Finally, regarding **Claim 30**, the cited art fails to provide, and the Examiner fails to point out, the claimed camming surface with rise-to-run of 2-to-1.

C. 35 U.S.C. §103 Rejection of Claims 1-13 and 25-36 over Sano in view of Comulada and further in view of Baum

The Examiner has rejected Claims 1-13 and 25-36 as being obvious over Sano in view of Comulada and further in view of Baum. Appellant respectfully disagrees with the Examiner's allegations for the following reasons.

Appellant incorporates the arguments provided in Sections VII (A) and (B), previously discussed at length. Appellant has previously addressed the same claim rejections in Sections VII (A) and (B) above wherein the Examiner failed to cite Baum. Appellant respectfully questions why the Examiner utilizes the Baum reference if the use of Sano and Comulada are suitable for rendering the invention obvious, as previously alleged by the Examiner. Appellant asserts that the Examiner's inclusion of an additional reference in rejecting the same group of claims is indicative of the failure of the previously argued rejections of Section VII (B).

Appellant incorporates the above arguments of Section VII (A) and (B) by reference herein. Accordingly, Appellant additionally addresses the Baum reference and asserts that the Examiner's proposed use of Baum in combination with Sano and Comulada fail to render the instant invention obvious.

Baum teaches a **composite** baseball bat with cavitied core. A veneer with preprinted logo is positioned on the composite bat. Col. 4, lines 54-65. The Examiner alleges in the final office action of June 14, 2007 that Baum discloses "the use of laser cutting in the formation of a baseball [bat] with a logo." After explaining to the Examiner that she mischaracterized the reference and that the laser is used to cut a veneer sheet and further that the veneer sheet has a logo which is imprinted by an epoxy ink, silk screen or branded, not laser engraved, the Examiner made the same statement in the January 24, 2008. In the pending rejection, the Examiner states, "Baum discloses the use of laser cutting in the formation of a baseball [bat] with a logo." See page 4, January 24, 2008 Office Action. The Examiner disregards the fact that Baum teaches laser cutting of a veneer sheet in forming a **composite bat** (not a baseball as repeatedly incorrectly stated in February 16, 2007 Office Action, June 14, 2007 Office Action

and January 24, 2008 Office Action). The Examiner also disregards the fact that Baum teaches a laser to cut a veneer sheet which is subsequently adhered to a composite baseball bat. The Examiner also alleges, incorrectly, that Baum uses, "laser cutting on the baseball bat." Moreover, Baum further teaches that the logo to which the Examiner refers is applied to the veneer [42] in a step independent of the laser. In other words, the laser is used to cut the veneer sheet, not to apply the logo to the veneer sheet [42] and the laser does not cut the bat. The logo is preprinted on the veneer. See Baum Col. 4, lines 61-63.

The use of the Baum bat in an engraving fixture would damage the Baum bat rendering the device inoperable for its intended use. The Baum laser is not used in any way to engrave the baseball bat directly. This is because the laser engraving would damage the Baum baseball bat. The Baum bat is a **composite** bat with a "wood-like veneer covering a layer of fiber reinforced resin." See Abstract. "The veneer outer surface overlays a fabric layer of high tensile strength, resin impregnated, fabric socks 24a, 24b....The fabric layer surrounds a core 28 formed of resilient urethane foam, wood, aluminum or the like..." Col. 4, lines 18-24. "Alternatively, the bat may be formed with a hollow core rather than a solid core 28." Col. 4, lines 45-46. In either embodiment, the Baum baseball bat only has a thin veneer layer and engraving of such would likely damage the underlying fabric layer(s). Such damage would weaken the bat therefore, Appellant asserts that the Examiner's has mischaracterized the Baum teaching and that the proposed modification would render Baum's bat inoperable for its intended use.

Additionally, as previously discussed in Section VII (A) and (B), the Sano fixture could not be used in the manner claimed, and therefore the claimed invention teaches away from the Sano reference. Sano teaches a movable clamp [12] which is rotatably positioned over the

workpiece. Assuming for sake of argument, that the Sano apparatus could be adapted to hold a baseball bat, the movable clamp [12] would be disposed on and over the upper half of the baseball bat so that a laser would not be able engrave the barrel of the baseball bat. Therefore the claimed invention teaches away from a proposed use of Sano. In the alternative, use of the Sano fixture for laser engraving a baseball bat would require removal of the upper movable clamp [12] which would render the Sano fixture inoperable for its intended use since Sano teaches the clamps [11,12] must be locked together for operation.

D. Response to Examiner's Response to Arguments

The Examiner makes several statements in the "Response" section, January 24, 2008 Office Action. Appellant questions the accuracy of various of those statements and Appellant incorporates sections A-C above in addressing the statements.

First, the Examiner admits that Sano fails to teach bats of varying diameter. Then the Examiner states that the Appellant's claim limitation is an intended use limitation. As previously discussed, the baseball bat is a positively recited structural limitation of several claims and therefore is not an intended use limitation. The Examiner disregards this for some unexplained reason in making the above allegation. Appellant again asserts that the bat is a positively recited structural limitation as discussed in the arguments previously.

Second, the Examiner states that Applicant argues the "camming surface and jaw movement is not taught." This is a mischaracterization, or at least a vague generalization, of the Appellant's arguments. Appellant asserts that the inter-relationship of movement of the base plate, relative to the base, jaws and camming surface is not taught or alternatively that the

relationship of distance moved by the base plate relative to jaw movement is not taught by Sano. This is due to the fact that the alleged base plate [41a] does not move.

Third, the Examiner states that the "workpiece in Sano et al. causes motion of the jaws, which is a functional equivalent motion." Appellant asserts that the Examiner is incorrect because the jaws of Sano may move with the workpiece, but workpieces of different sizes would be at different positions relative to a laser engraver because of the lack of a movable base plate and because the jaw movement is not related to movement of the base plate. Therefore, the Examiner's allegation of a functional equivalent is incorrect and inappropriate. Moreover, the cited art fails to meet the claim limitation that the Examiner attempts to address.

VIII. CONCLUSIONS

For the extensive reasons set forth herein above, Appellant respectfully contends that each claim pending in the present application is allowable their current form. Therefore, reversal of all rejections is courteously solicited.

Respectfully submitted,

Dated: January 2, 2009

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IX. CLAIMS APPENDIX

1. (Previously Presented) An automatic leveling fixture, comprising:

a base;

at least one jaw being slidably connected to said base;

a base plate being slidable relative to said base;

said at least one jaw having an angled base plate camming surface engaging said base plate causing said at least one jaw to move a preselected distance relative to a distance moved by said base plate;

a bat engaging said at least one jaw and said base plate when said leveling fixture moves said bat to a preselected position.

2. (Original) The automatic leveling fixture of claim 1, said at least one jaw being a first jaw and a second jaw.

3. (Original) The automatic leveling fixture of claim 2, said first jaw and said second jaw each moving one-half the distance moved by said base plate.

4. (Original) The automatic leveling fixture of claim 1, further comprising a jaw channel extending through said base in a latitudinal direction.

5. (Original) The automatic leveling fixture of claim 4, said at least one jaw sliding relative to said base through said jaw channel.

6. (Original) The automatic leveling fixture of claim 5, said jaw channel having a rail positioned therein.

7. (Original) The automatic leveling fixture of claim 1, said at least one jaw being two opposed jaws.

8. (Original) The automatic leveling fixture of claim 7, said two opposed jaws being biased inwardly toward said base plate.

9. (Original) The automatic leveling fixture of claim 8, said two opposed jaws being biased by a compression spring extending through said opposed jaws.

10. (Original) The automatic leveling fixture of claim 9, said two opposed jaws being mounted on a rail and slidable relative to said base.

11. (Original) The automatic leveling fixture of claim 1, said at least one jaw having a tapered receiving surface.

12. (Previously Presented) The automatic leveling fixture of claim 1, further comprising camming rollers mounted within a notch of said base plate and slidably engaging said angled base plate camming surface of said at least one jaw.

13. (Original) The automatic leveling fixture of claim 1, said fixture receiving bats of varying diameter and position said bats at equal elevations relative to a laser.

25. (Previously Presented) An automatic leveling fixture, comprising:

a base plate slidably positioned in a base;

a first jaw and a second jaw slidably adjustable relative to said base;

said first jaw and said second jaw biased toward said base plate;

said first jaw and said second jaw each having an inwardly directed base plate camming surface for directing said base plate a preselected distance in relation to movement of said jaws;

a bat leveled by engagement of said bat with said first jaw, said second jaw and said base plate.

26. (Previously Presented) The automatic leveling fixture of claim 25, said base plate having at least one guide post slidably engaging said base through an aperture in said base.

27. (Previously Presented) The automatic leveling fixture of claim 25, further comprising camming rollers engaging each of said base plate camming surface.

28. (Previously Presented) The automatic leveling fixture of claim 25, said first jaw, said second jaw, and said base plate each having tangential contact with said bat placed in said automatic leveling fixture.

29. (Previously Presented) The automatic leveling fixture of claim 25, said first jaw and said second jaw each moving one-half of a distance moved by said base plate.

30. (Previously Presented) The automatic leveling fixture of claim 25, said base plate camming surface having a rise-to-run ratio of 2-to-1.

31. (Previously Presented) The automatic leveling fixture of claim 25, said fixture receiving bats of varying diameter and repeatably positioning a peripheral edge of each bat at a preselected elevation.

32. (Previously Presented) An automatic leveling fixture, comprising:

a base;

at least one jaw;

at least one base plate moving relative to movement of said at least one jaw by an angled camming surface operably engaging said base plate and said at least one jaw;

a bat engaged by said at least one plate and said at least one jaw;

wherein said fixture retains bats of varying diameter at equal elevations regardless of the bat diameter.

33. (Previously Presented) An automatic leveling fixture, comprising:

a base;

a least one jaw slidable in a horizontal plane;

a base plate slidable through a vertical plane a distance relative to said sliding of said at least one jaw;

an angled camming surface extending between said at least one jaw and said base plate providing motion of said base plate relative to said at least one jaw and wherein said base plate is movable relative to said base, said at least one slidable jaw and said angled camming surface;

said automatic leveling fixture controlling lateral positioning and height of a bat in a repeatable manner regardless of the diameter of a bat.

34. (Previously Presented) An automatic leveling fixture, comprising:

a base plate in contact with a bat;

a first and second slidable jaw in contact with opposite sides of said bat;

wherein said first and second jaws are in slidable contact with said base plate;

a marking device adjacent said bat;

wherein said first and second jaw slidably receive said bat and cause said base plate to modify the vertical position of said bat to maintain an equal distance of said bat to said marking device regardless of said bat diameter.

35. (Previously Presented) An automatic leveling fixture, comprising:

a fixture apparatus which repeatedly positions bats of varying diameter at a preselected elevation, wherein a peripheral edge of any one of said bats has an equilateral cross-section;

said fixture comprising a pair of slidable jaws, a camming surface engaging said pair of slidable jaws and a base plate, said base plate movable relative to a fixture base, said camming surface and said pair of jaws;

said fixture apparatus further repeatedly positioning a center point of each of said bats at a preselected longitudinal and latitudinal position.

36. (Previously Presented) An automatic leveling fixture, comprising:

a base;

opposed jaws slidably connected to said base;

a base plate being slidable relative to said base and said opposed jaws;

a base plate camming surface extending from said opposed jaws and engaging said base plate causing said jaws to move a preselected distance relative to a distance moved by said base plate.

X. EVIDENCE APPENDIX

Exhibit A

US006705372B2

(12) **United States Patent**
Sano et al.

(10) **Patent No.: US 6,705,372 B2**
(45) **Date of Patent: Mar. 16, 2004**

(54) **TUBE CONNECTING APPARATUS**

(75) Inventors: **Hiroaki Sano**, Nakakoma-gun (JP); **Narukuni Nakada**, Fujinomiya (JP); **Akihiko Iguchi**, Kasugai (JP); **Yoshiyuki Yamada**, Kasugai (JP); **Masashi Yanagawa**, Kasugai (JP); **Takeshi Minatani**, Kasugai (JP)

(73) Assignee: **Terumo Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/192,494**

(22) Filed: **Jul. 11, 2002**

(65) **Prior Publication Data**

US 2002/0174956 A1 Nov. 28, 2002

Related U.S. Application Data

(62) Division of application No. 09/557,826, filed on Apr. 25, 2000, now Pat. No. 6,463,979.

(30) **Foreign Application Priority Data**

Apr. 27, 1999 (JP) 11-120157

(51) **Int. Cl.**[7] **B29C 65/78**; B29C 65/18; A61M 39/00; B29L 23/00

(52) **U.S. Cl.** **156/503**; 156/158; 156/159; 156/268; 156/304.6; 156/308.4; 156/308.2; 156/365; 156/510; 156/556; 425/108; 269/2; 269/37; 269/43; 269/58; 269/59; 269/71; 269/72; 269/329; 277/314

(58) **Field of Search** ..... 425/108; 277/314; 156/503, 510, 159, 258, 304.6, 308.4, 556, 158, 308.2, 365; 269/2, 43, 37, 58, 59, 60, 61, 62, 71, 72, 902, 329; 29/33 T; 604/905

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,610,670	A	9/1986	Spencer	604/29
5,802,689	A	9/1998	Sano	29/33 T
6,026,882	A	2/2000	Yamada et al.	156/433

FOREIGN PATENT DOCUMENTS

EP	0105587	4/1984
EP	0639384	2/1995
EP	0778123	6/1997
FR	2578782 A1	9/1986
JP	07329182	12/1995
JP	11348128	12/1999

Primary Examiner—Linda Gray
(74) *Attorney, Agent, or Firm*—Oliff & Berridge, PLC

(57) **ABSTRACT**

A buckle pivotally arranged in a movable clamp **12** of a first tube holder **1** is attached with play to a buckle **120** pivotally arranged in a movable clamp **82** of a second tube holder **2**. When tubes are held in the first and second tube holders **1** and **2**, release of the tubes from the holders **1** and **2** is prevented by a movement of a plunger **203** in correspondence of excitation and demagnetization of a solenoid **202** for a predetermined period of operation of the apparatus after holding the tubes (i.e., for a period required from the locking of the buckle **120** until the completion of moving-down of a wafer holder).

4 Claims, 19 Drawing Sheets

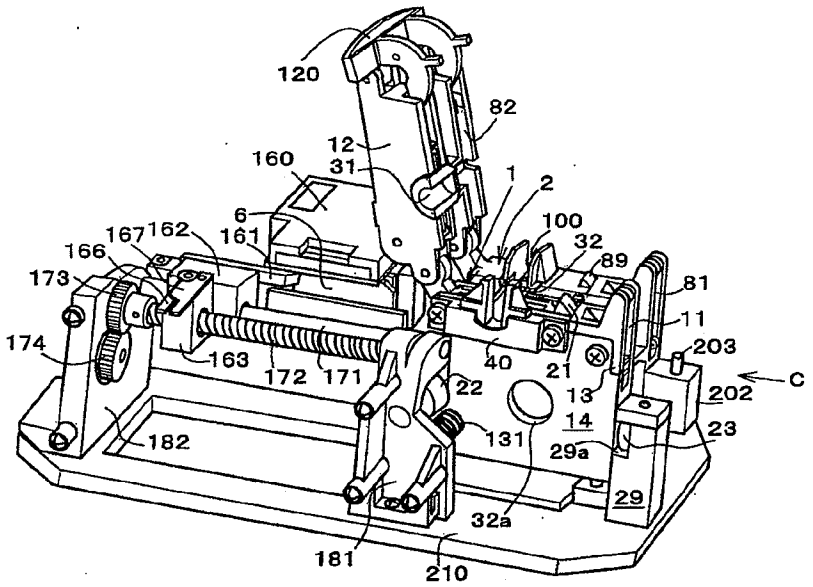
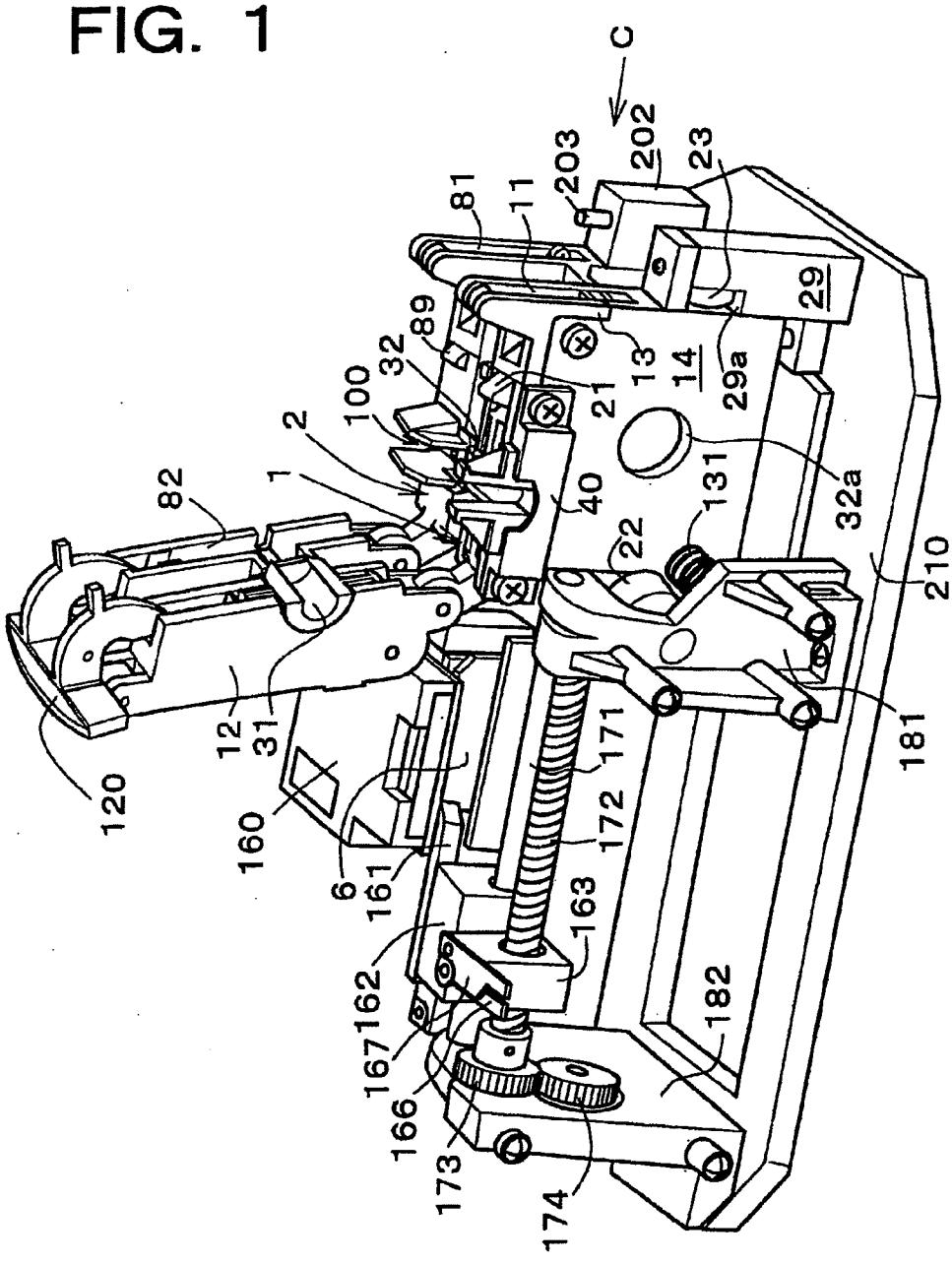


FIG. 1


C
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203
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1
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32a
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210
12
31
171
181
120
160
172
6
161
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182
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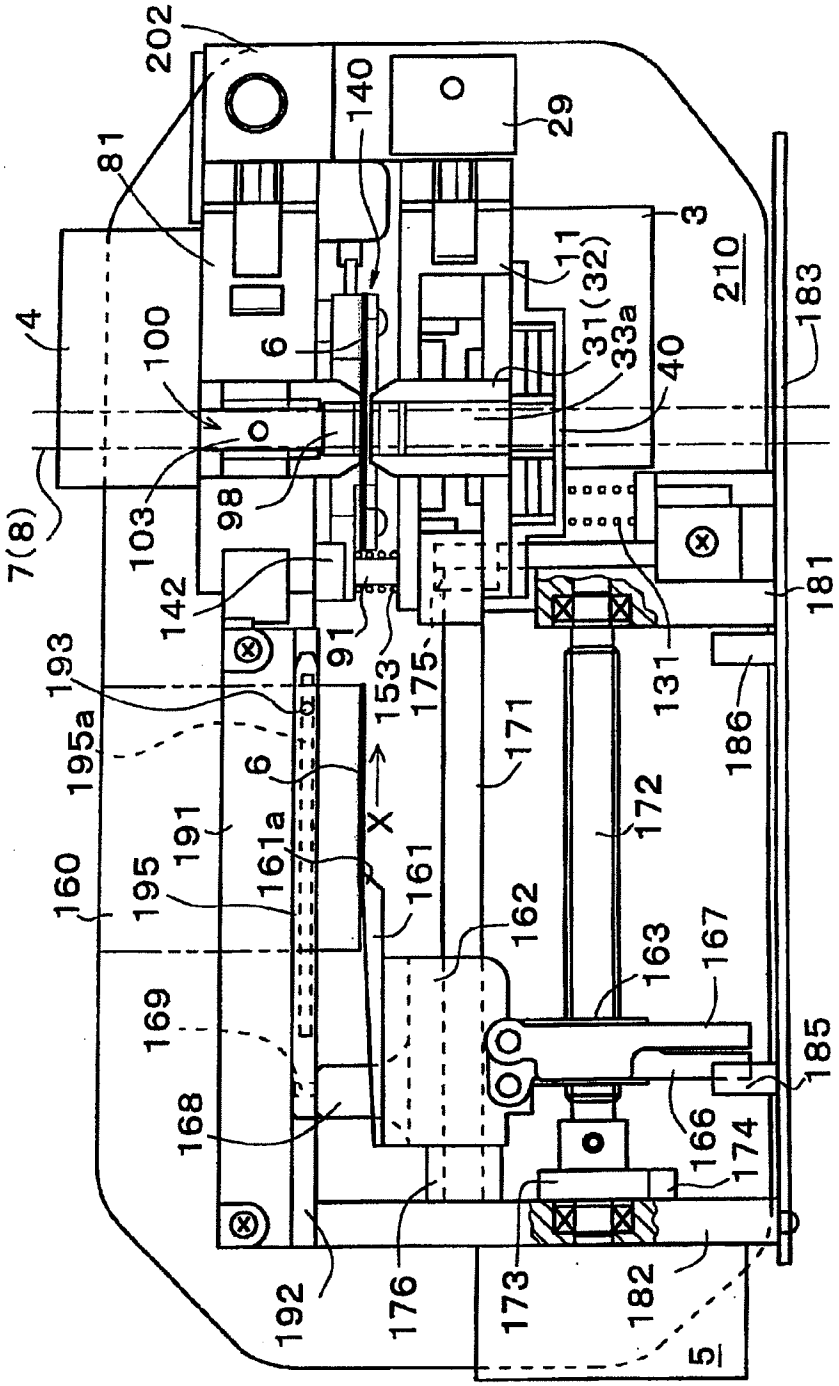
173
174

FIG. 2


202
140
29
81
3
210
11
31(32)
33a
40
183
4
100
6
7(8)
103
98
142
91
153
175
171
131
181
193
195a
186
172
191
161a
161
162
163
167
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195
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174
176
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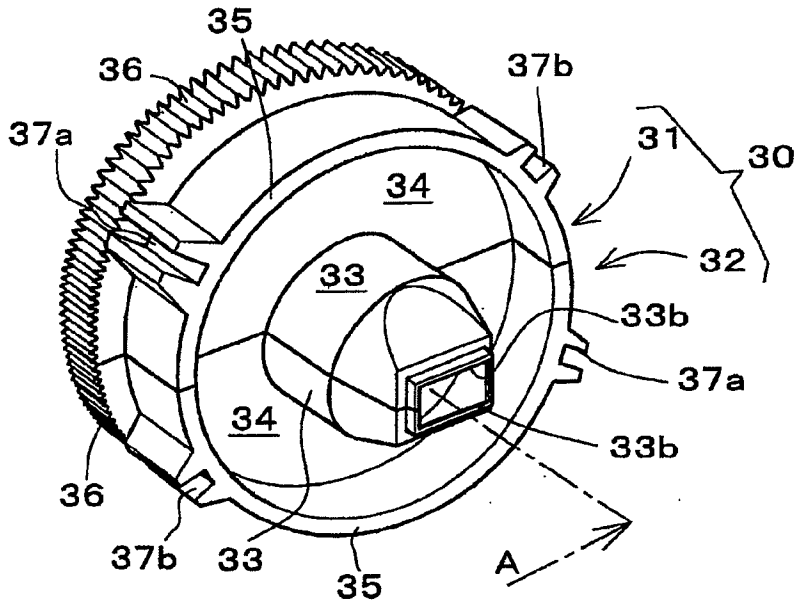
182
192
5

FIG. 3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36
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30
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37b
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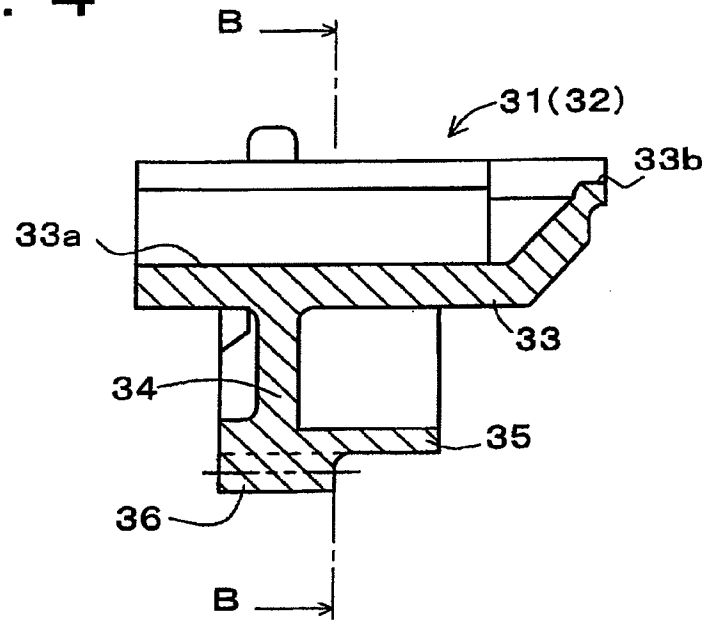
35
A

FIG. 4


B
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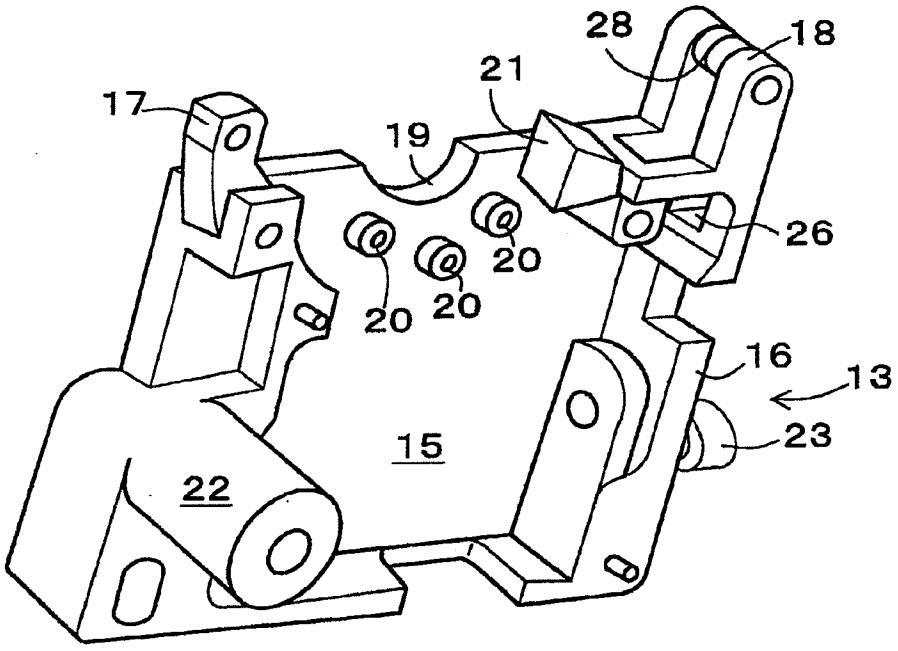
33
34
35
36
B

FIG. 5



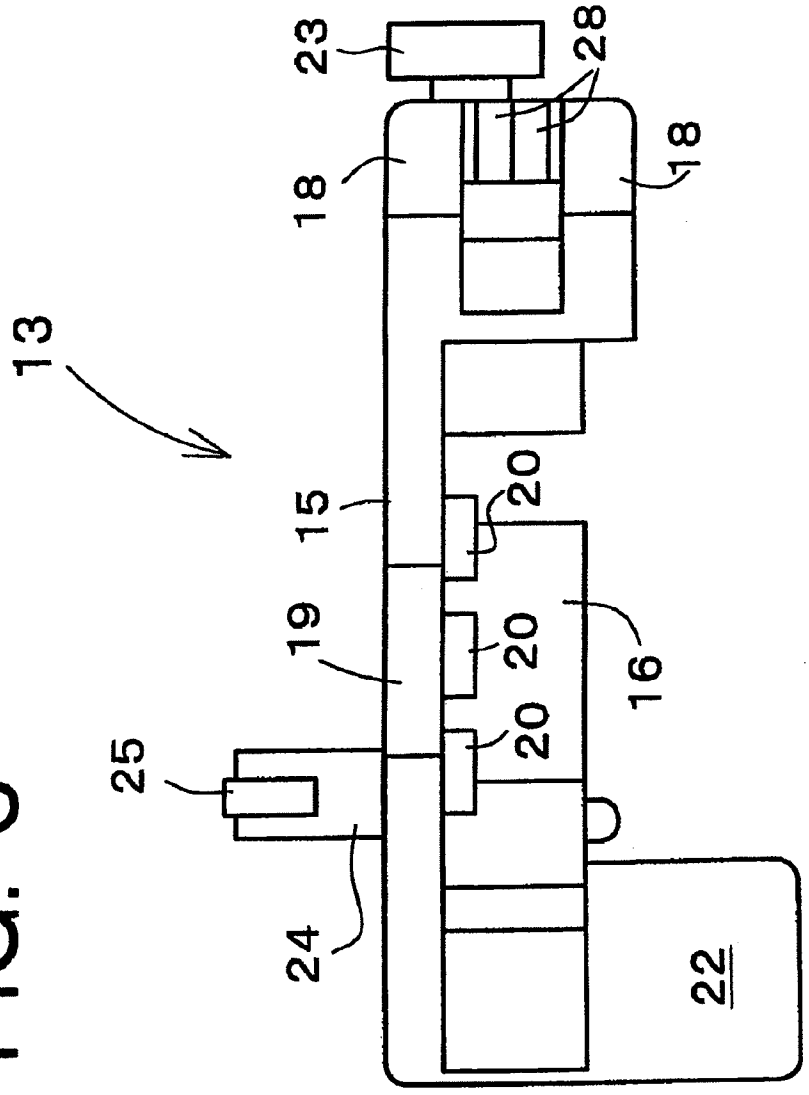
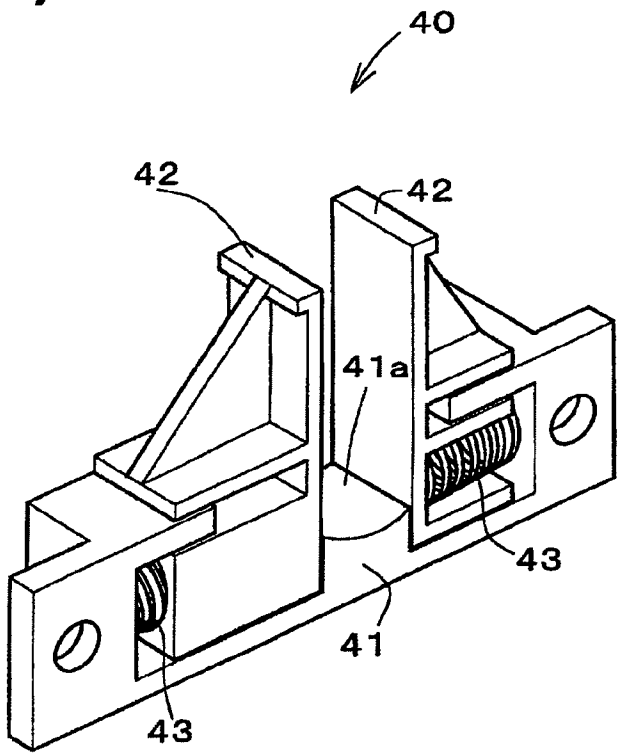


FIG. 6

FIG. 7



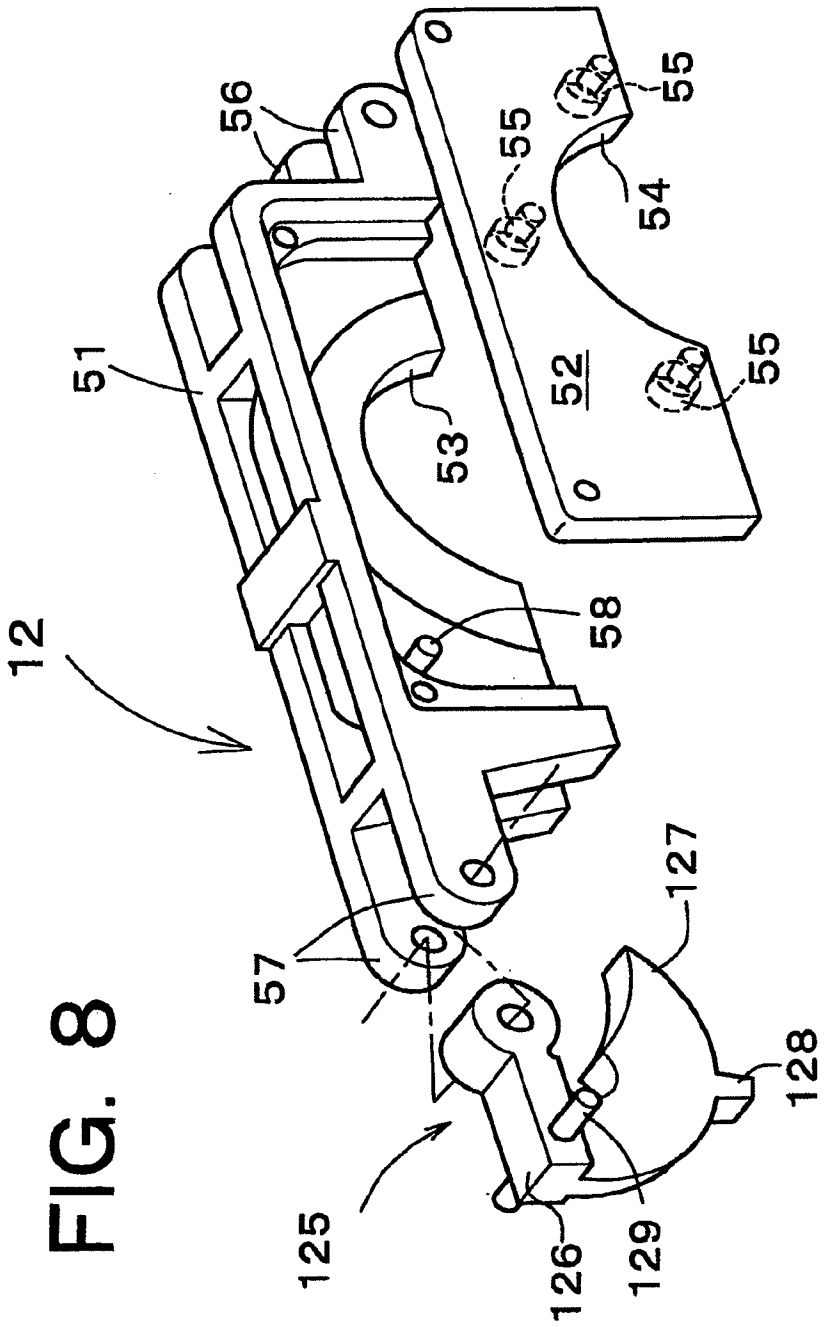
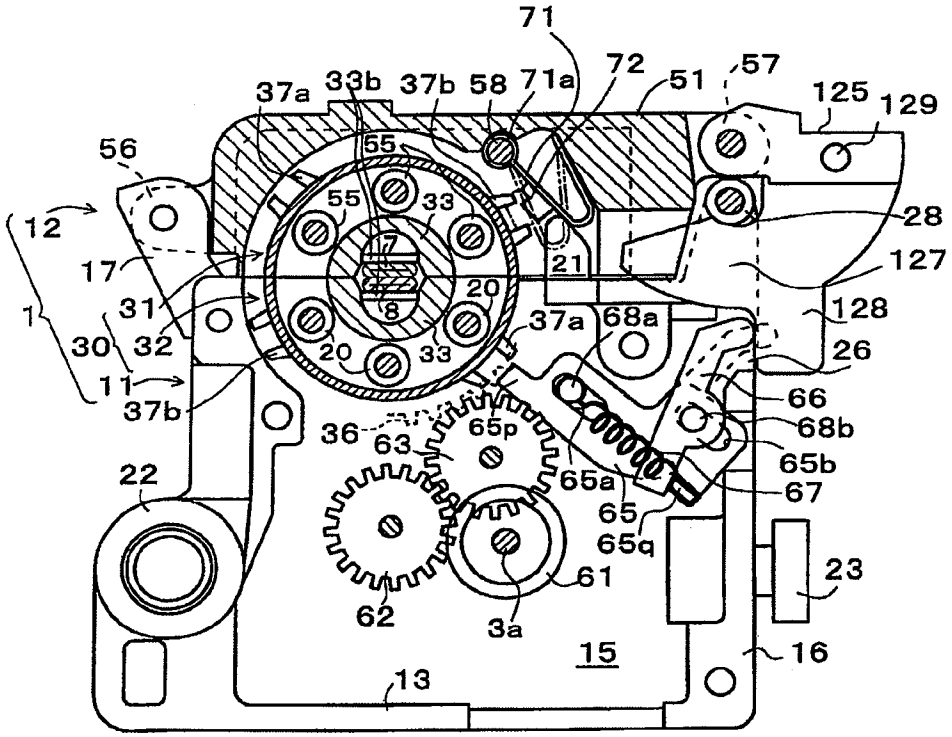


FIG. 8

FIG. 9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71a
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129
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33
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127
31
20
8
37a
68a
128
30
32
20
33
26
11
37b
66
36
63
65p
68b
65b
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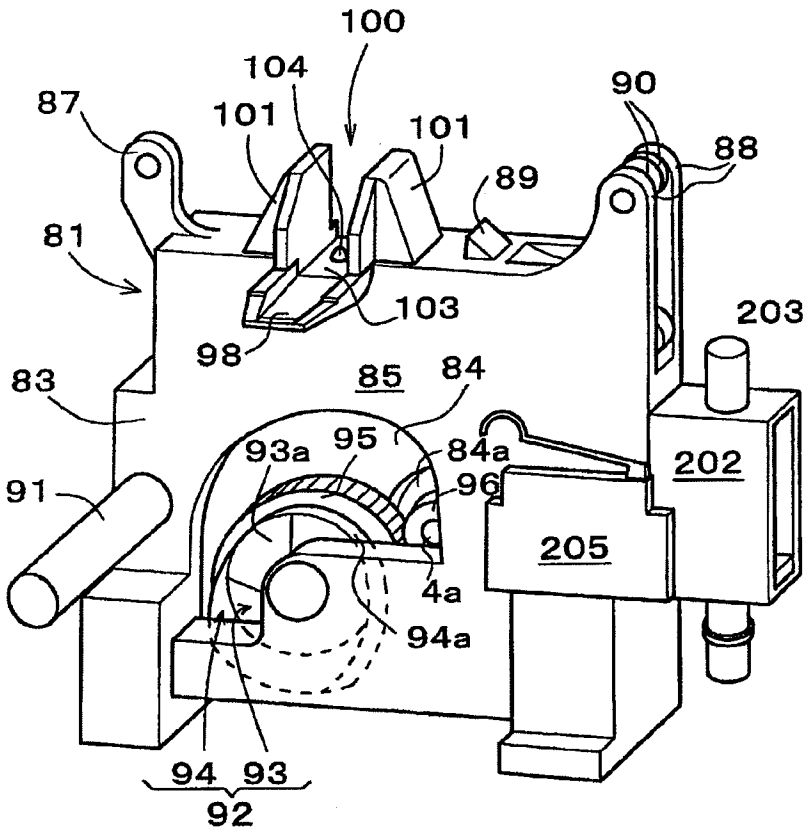
65a
67
65
65q
23
61
62
3a
15
16
13

FIG. 10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101
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88
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81
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203
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84a
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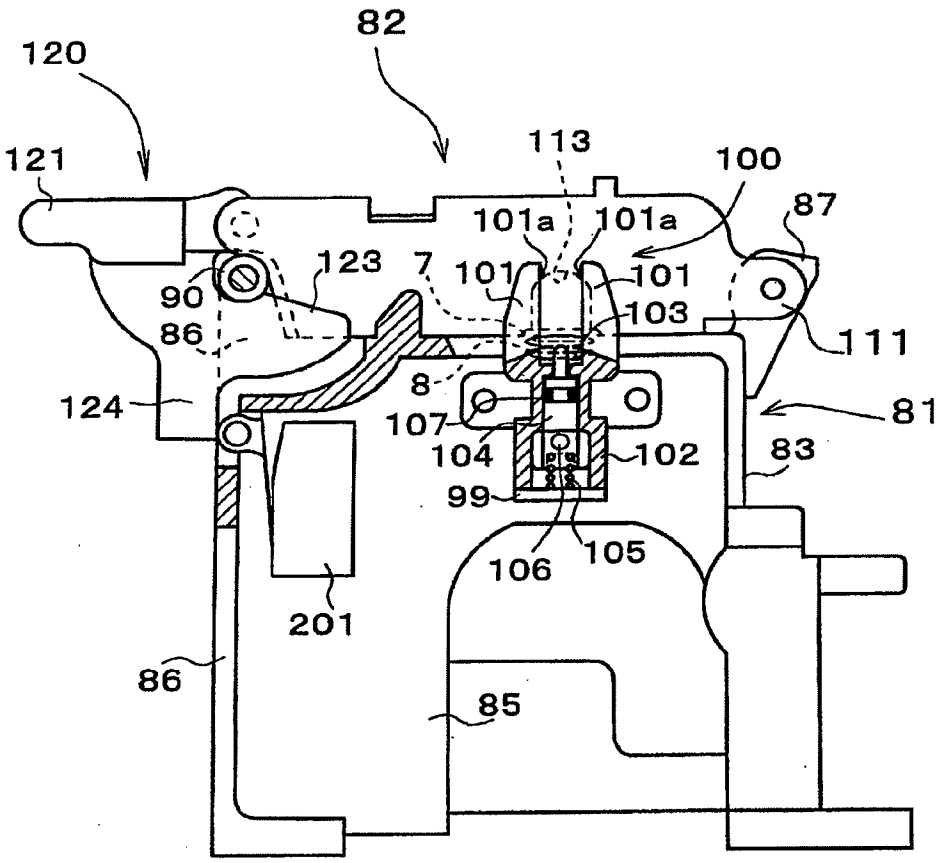
91
96
205
4a
94a
94
93
92

FIG. 11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7
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83
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201
86
85

FIG. 12

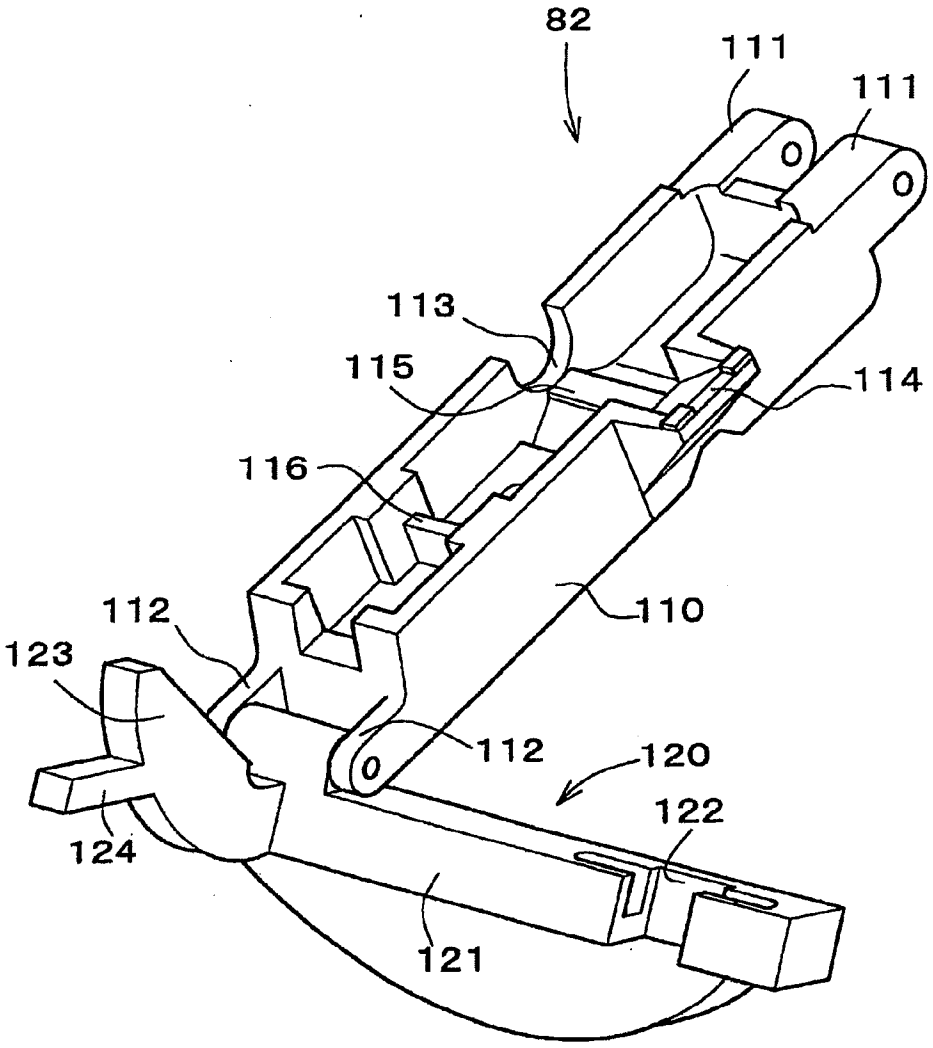


FIG. 13

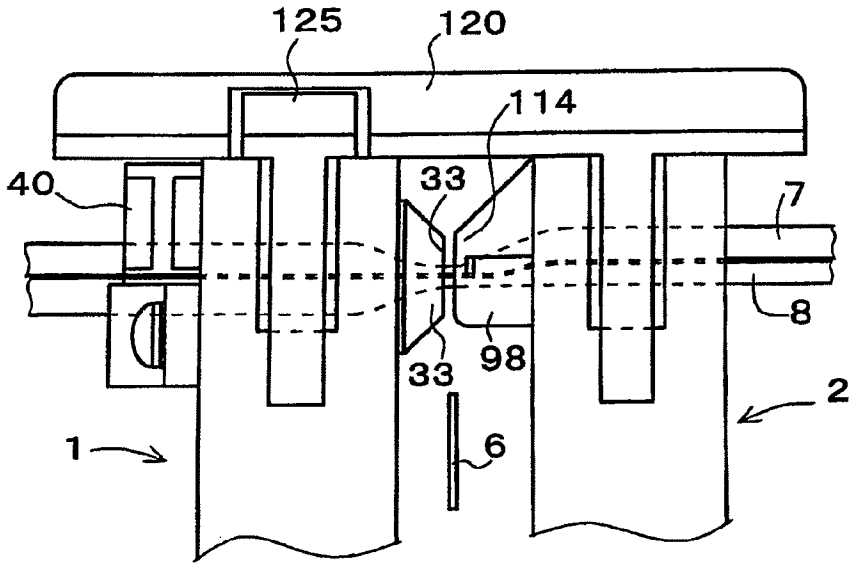
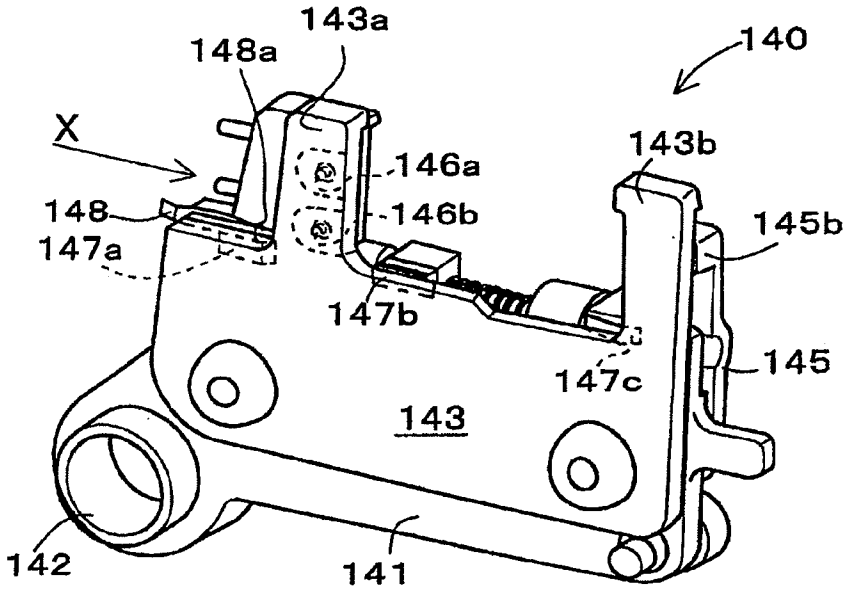


FIG. 14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147b
145
147c
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142
141

FIG. 15

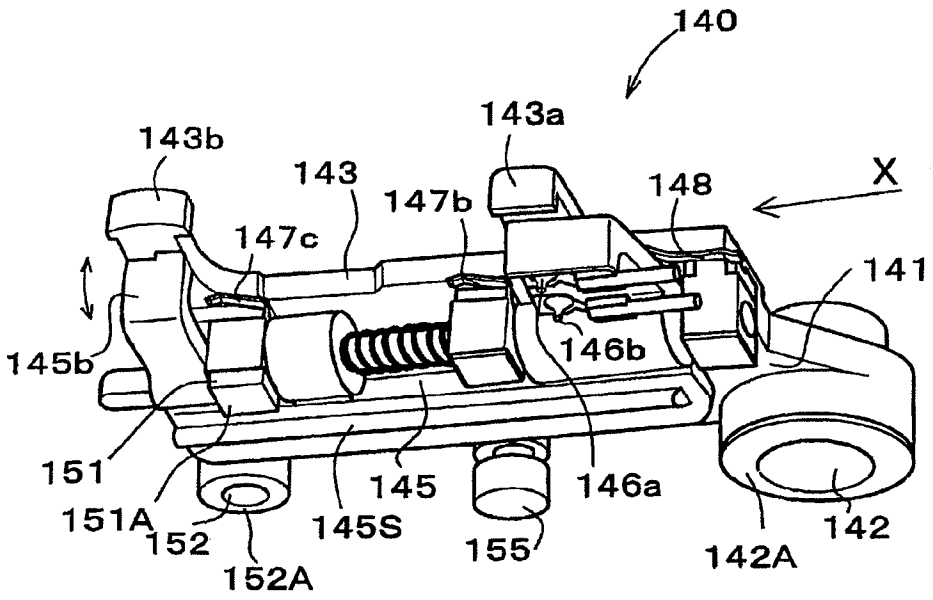
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FIG. 16

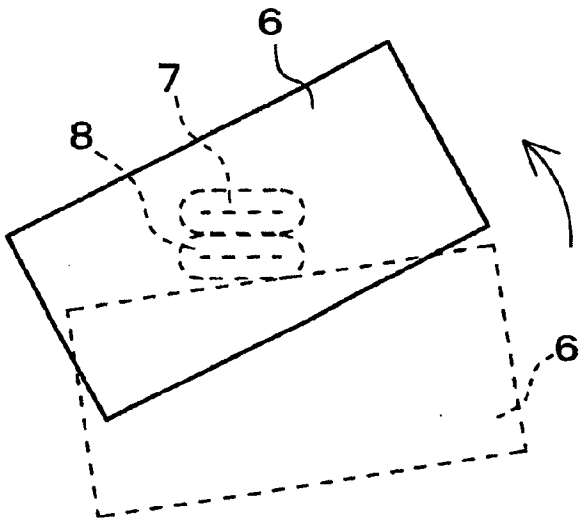


FIG. 17A

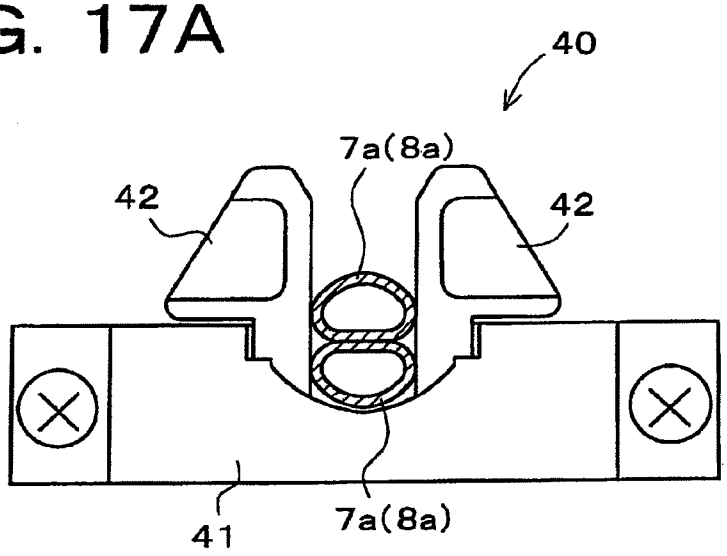


FIG. 17B

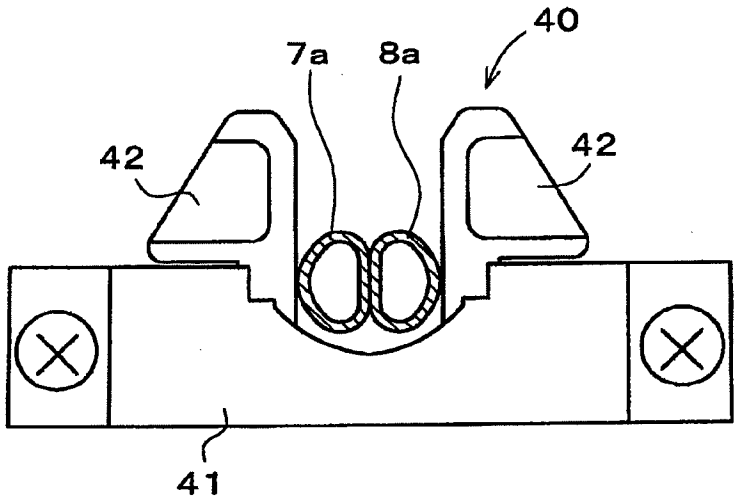


FIG. 18 PRIOR ART

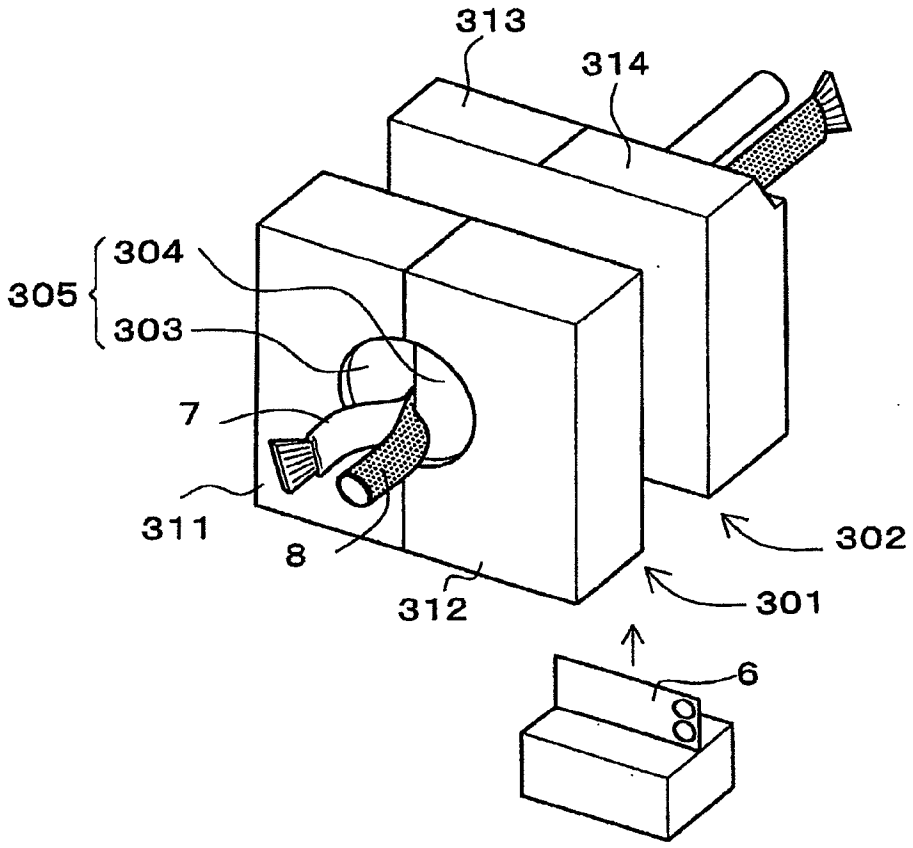


FIG. 19

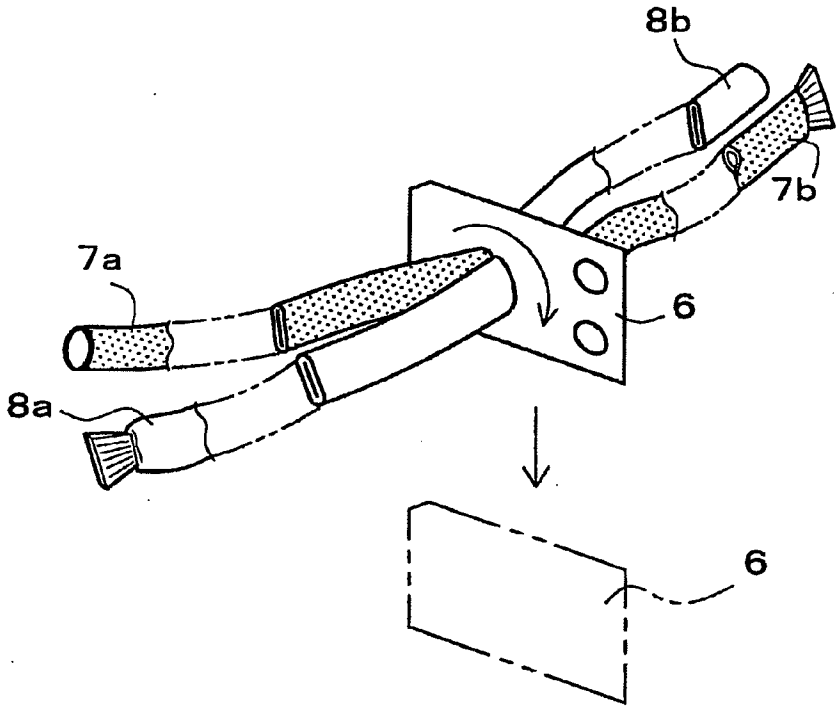


FIG. 20

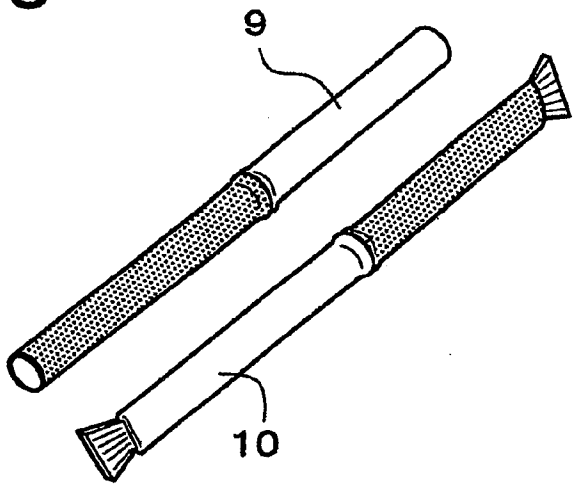
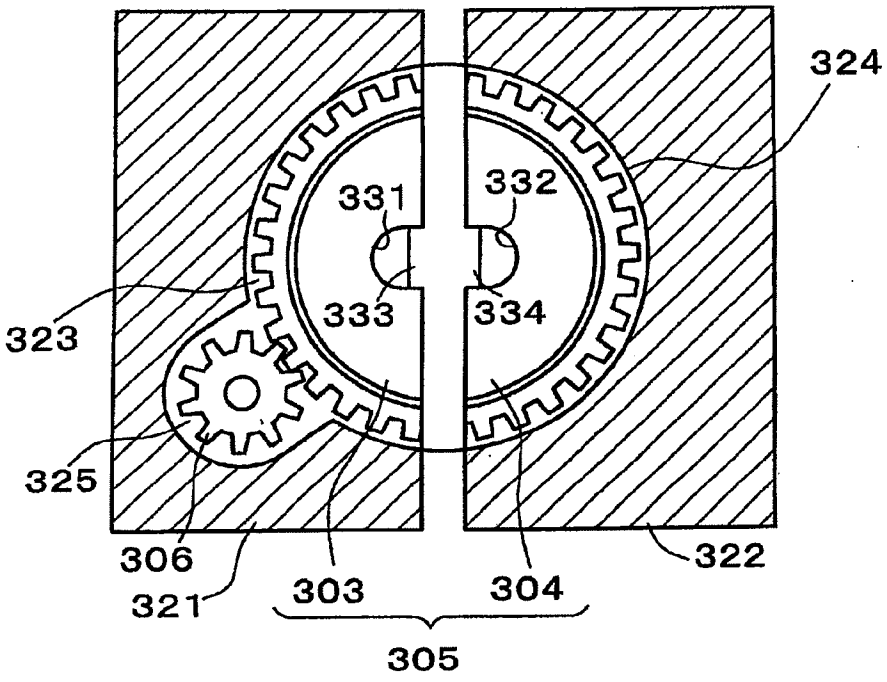


FIG. 21 PRIOR ART



TUBE CONNECTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of Invention

The present invention relates to a tube connecting apparatus for melting to cut flexible tubes and for connecting the tubes by mutually contacting the cut end faces.

2. Description of Related Art

A tube connecting apparatus is used, for instance, for providing a dialysis solution into an abdominal cavity of a patient who requires Continuous Ambulatory Peritoneal Dialysis (CAPD) by providing connection between a transfer tube connected with the abdominal cavity and a tube connected with a dialysis pack.

An example for connecting operations of a tube connecting apparatus will be briefly explained below. As exemplarily shown in FIG. **18**, two tubes **7,8** are grasped at two portions, that is, between a fixed clamp **311** and a movable clamp **312** of a first tube holder **301** and between a fixed clamp **313** and a movable clamp **314** of a second tube holder **302**. The movable clamps **312, 314** are moved into contact with, and away from, the fixed clamps **311, 313**. The tubes **7,8** grasped by the first tube holder **301** and the second tube holder **302** are squeezed flat in cross section, closing the interior of the tubes.

Then, a heated cutting plate (hereinafter referred to as "wafer") **6** is moved upwards between the first tube holder **301** and the second tube holder **302**, thereby melting to vertically cut the tubes **7,8**.

In the first tube holder **301** is provided a pair of semicircular rotor pieces **303, 304** which are made into contact with each other to constitute a clamp rotor **305**.

After the cutting of the tubes **7, 8**, the rotation of the clamp rotor **305** grasping the cut tubes (*7a, 8a*) of one side of the tubes (**7, 8**), as shown in FIG. **19**, inverts the cut tubes *7a, 8a* while allowing their cut end faces to slide along a side surface of the wafer **6**.

Upon completion of inversion of the cut tubes *7a,8a*, the wafer **6** is retracted when the cut end faces of mutually different tubes (*7a* and *8b*, *8a* and *7b*) are positioned coaxially, facing each other, and the cut end faces of the different tubes are pressed to each other to be welded. Thus, two tubes **9, 10** are formed as illustrated in FIG. **20**.

The above described tube connecting apparatus is arranged such that inversion of the cut tubes is performed by the clamp rotor **305** structured of the pair of rotor pieces **303, 304**. FIG. **21** is a sectional view of the clamp rotor **305** mounted in the first tube holder **301**.

The clamp rotor **305** is constructed of the pair of semicircular rotor pieces **303, 304** with teeth formed on the periphery thereof, and is so constituted as to make one gear when the rotor pieces **303,304** come in contact with each other. At a center of the clamp rotor **305**, that is, at the center of the contact surfaces of the rotor pieces **303, 304**, U-shaped grooves **331, 332** are formed deep enough to allow the insertion of one tube, and closing portions **333, 334** are provided forming shallow grooves to squeeze and grasp the tubes.

The rotor pieces **303, 304** are respectively mounted in rotor mounting portions **323, 324** formed in blocks **321, 322** constituting the fixed clamp **311** and the movable clamp **312**.

On the other hand, a drive gear **306** which is in mesh with the rotor piece **303(304)** is rotatably mounted in a gear

mounting portion **325** formed continuously to the rotor mounting portion **323**. The drive gear **306** is further connected to a motor shaft of a driving motor (not illustrated).

When the tubes **7, 8** are grasped and then cut as shown in FIG. **18**, the unillustrated driving motor is driven at a specified timing such that rotation is transmitted to the driving gear **306**. In this manner, the clamp rotor **305** is rotated within the first tube holder **301** and the rotor pieces **303, 304** are turned to change places of cut tubes *7a, 8a*.

However, the conventional tube connecting apparatus mentioned above has the following disadvantages.

(1) The first and second holders **301, 302** need to be moved closer to each other for securing operations of pressing the cut end faces of the tubes to each other after retracting the wafer **6**. Therefore, for clamping the tubes **7, 8** by the first tube holder **301** and the second tube holder **302**, the movable clamp **312** is fixed to the fixed clamp **311** and, separately therefrom, the movable clamp **314** is fixed to the fixed clamp **313**. In this way, in order to fix the movable clamps **312, 314** to the fixed clamps **311, 313**, similar works need to be repeated, regardless of manually or automatically, thereby causing useless redundancy in view of operation as well as structural arrangement.

(2) The conventional tube connecting apparatus employing the clamp rotor **305** is arranged such that the rotor pieces **303, 304** are exposed to the exterior when the blocks **321, 322** are separated. In case the user presses the rotor pieces **303, 304**, therefore, the rotor pieces **303, 304** will be displaced from each position after tube connection where the tubes are held symmetrically with respect to each other.

Thus, in case the rotor pieces **303, 304** should be made contact with each other as being still displaced, either one will be pushed by the other to be slightly rotated. Thus the clamp rotor **305** will be misaligned relative to a reference condition in which the rotor pieces **303, 304** are accurately mounted in symmetric relation to each other in the blocks **321, 322** as shown in FIG. **21**. Accordingly, if the apparatus is actuated in this condition with the tubes **7, 8** not being clamped symmetrically, misalignment of the cut end faces of the tubes **7, 8** is caused by inversion of the clamp rotor **305**, which may result in connection errors.

(3) While the tubes **7, 8** are clamped by the first and second tube holders **301, 302**, if the movable clamps **312, 314** are erroneously separated from the fixed clamps **311, 313** before the tubes **9, 10** are alternately joined to each other, the tubes **7, 8** will be released from the first and second holders **301, 302**. As a result, the alternate joining of the tubes **9, 10** can not be ensured. It is therefore necessary to prevent the fixed clamps **311, 313** from being separated from the movable clamps **312, 314** before completion of alternate connection of the tubes. However, the conventional apparatus is not provided with functions for reliably preventing such separation.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above circumstances and has an object to overcome the above problems and to provide a tube connecting apparatus capable of reliably performing connection of tubes.

Additional objects and advantages of the invention will be set forth in part in the description which follows and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the purpose of the invention, there is provided a tube connecting apparatus including: a first tube holder provided with a pair of holding members for holding a plurality of flexible tubes; a second tube holder provided with a pair of holding members for holding the plurality of flexible tubes; cutting and connecting means for heating and melting the plurality of flexible tubes held in the first tube holder and the second tube holder to cut the tubes by a heated cutting plate which is moved between the first tube holder and the second tube holder and to connect the tubes cut by the cutting plate by contacting cut end faces of the cut tubes held in the first tube holder with those of the cut tubes held in the second tube holder, the cut tubes to be connected being parts of originally different tubes; and joining members for integrally connecting one of the pair of holding members of the first tube holder to one of the pair of holding members of the second tube holder, the joining members being arranged so that one of the tube holders is movable with respect to the other tube holder.

In the above tube connecting apparatus of the invention, the joining members integrally connect one of the pair of holding members of the first tube holder to one of the pair of holding members of the second tube holder so that the first tube holder may be moved with respect to the second tube holder. This makes it possible to ensure movements of the tube holders to press the cut end faces of the different tubes to be connected. Furthermore, ones of the holding members which are connected by the joining member can be moved integrally without the need for individual manipulation of the connected holding members, thereby improving operability of the holding members.

In the above tube connecting apparatus, preferably, the joining members are of buckle configurations, specifically, the joining members include a first buckle member and a second buckle member movably attached to the first buckle member, and the first and second buckle members are provided integrally in the holding members each being one of the pair of holding members of the first and second tube holders.

According to such the tube connecting apparatus, the first and second buckles are provided integrally in the holding members. Even if the holding members of the first and second tube holders are integrally connected by the joining members to each other, the joining members including the buckles provided in the holding members enables movements of the tube holders to press the cut end faces of the different tubes to be connected. Furthermore, ones of the holding members which are connected by the joining member with the first and second buckles can be moved integrally without the need for individual manipulation of the connected holding members, thereby improving operability of the holding members.

It is further preferable that the above tube connecting apparatus includes release preventing means for preventing, under predetermined conditions, release of the tubes from the first tube holder and the second tube holder after the plurality of flexible tubes are held in the first tube holder and the second tube holder.

Preferably, the predetermined conditions include a period required until completion of connection of the tubes.

Preferably, the release preventing means includes a solenoid and an engaging member, and release of the tubes held from the first tube holder and the second tube holder is prevented by the engaging member that moves in accordance with excitation and demagnetization of the solenoid.

According to the above tube connecting apparatus, after the first and second tube holders hold therein the tubes, under the predetermined conditions, the release preventing means prevents release of the tubes from the first and second tube holders. Specifically, in association with the excitation and demagnetization of the solenoid, the engaging member is moved to prevent the first and second tube holders from erroneously releasing the tubes held therein until completion of connection of the tubes. Thus, the cut tubes of one side of the tubes, after mutually translocated, can be reliably connected to the other cut tubes.

According to another aspect of the present invention, there is provided a tube connecting apparatus including: a first tube holder provided with a pair of holding members for holding a plurality of flexible tubes; a second tube holder provided with a pair of holding members for holding the plurality of flexible tubes; cutting and connecting means for heating and melting the plurality of flexible tubes held in the first tube holder and the second tube holder to cut the tubes by a heated cutting plate which is moved between the first tube holder and the second tube holder and to connect the tubes cut by the cutting plate by contacting cut end faces of the cut tubes held in the first tube holder with those of the cut tubes held in the second tube holder, the cut tubes to be connected being parts of originally different tubes; and release preventing means for preventing, under predetermined conditions, release of the tubes from the first tube holder and the second tube holder after the plurality of flexible tubes are held in the first tube holder and the second tube holder.

In the above tube connecting apparatus, after the first and second tube holders hold therein the tubes, under the predetermined conditions, the release preventing means prevents release of the tubes from the first and second tube holders. Thus, the tubes can be surely held in the first and second tube holders until completion of connection of the tubes, so that the cut tubes of one side of the tubes, after mutually translocated, can be reliably connected to the other cut tubes.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification illustrate an embodiment of the invention and, together with the description, serve to explain the objects, advantages and principles of the invention.

In the drawings,

FIG. **1** is a perspective view of an internal structure of a tube connecting apparatus in an embodiment according to the present invention;

FIG. **2** is a plan view of the tube connecting apparatus in the embodiment;

FIG. **3** is a perspective view of a clamp rotor of the tube connecting apparatus in the embodiment;

FIG. **4** is a sectional view of a rotor piece viewed from the direction indicated by an arrow A in FIG. **3**;

FIG. **5** is a perspective view of a fixed clamp body of the tube connecting apparatus in the embodiment;

FIG. **6** is a plan view of the fixed clamp body shown in FIG. **5**;

FIG. **7** is a perspective view of a tube guide of the tube connecting apparatus in the embodiment, showing a mounting surface side with respect to a body cover;

FIG. **8** is a perspective exploded view of a movable clamp of a first tube holder of the tube connecting apparatus in the embodiment;

FIG. **9** is a sectional view of the first tube holder in the embodiment;

FIG. **10** is an external perspective view of a fixed clamp of a second tube holder in the embodiment;

FIG. **11** is a side view of the fixed clamp body of the second tube holder in the embodiment;

FIG. **12** is a perspective view of the movable clamp and a buckle in the embodiment;

FIG. **13** is a front view of the first and second tube holders viewed from the direction indicated by an arrow C in FIG. **1**;

FIG. **14** is a perspective view of a wafer holder viewed from the first tube holder side in the embodiment;

FIG. **15** is a perspective view of the wafer holder viewed from the second tube holder side in the embodiment;

FIG. **16** is an explanatory view of showing a position of the wafer which cuts tubes;

FIGS. **17**A and **17**B are side views of the tube guide in the embodiment, showing a state of clamping tubes;

FIG. **18** is a perspective view of a tube clamping part of a conventional tube connecting apparatus;

FIG. **19** is an explanatory view of showing tubes in cutting and inversion;

FIG. **20** is a perspective view of resultant tubes after connection between different tubes; and

FIG. **21** is a sectional view of an inverting mechanism of the conventional tube connecting apparatus.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A detailed description of a preferred embodiment of a tube connecting apparatus embodying the present invention will now be given referring to the accompanying drawings. FIG. **1** is a perspective view of an internal arrangement of the tube connecting apparatus in the present embodiment. FIG. **2** is a plan view thereof (while movable clamps **12**, **82** are omitted).

The tube connecting apparatus includes a tube holding mechanism for holding tubes, a cutting mechanism for moving a cutting plate, or a wafer **6**, with respect to the tubes, and a wafer transferring mechanism for transferring a new wafer **6** for each tube connecting operation. The arrangement of the tube holding mechanism will be first explained.

The tube holding mechanism is for holding and grasping two tubes **7**, **8** set one on top of the other at two portions, vertically inverting cut tubes of one side of the tubes after cutting, and pressing the cut end faces of the inverted tubes to those of the other cut tubes to connect the cut ends of different tubes. The tube holding mechanism is mainly constructed of a first tube holder **1** and a second tube holder **2**. The first tube holder **1** is provided with a fixed clamp **11** and a movable clamp **12** which is connected to the fixed clamp **11** by a pin joint. Similarly, the second tube holder **2** is provided with a fixed clamp **81** and a movable clamp **82** connected to the fixed clamp **81** by a pin joint. It is to be noted that the fixed clamps **11**, **81** and the movable clamps **12**, **82** correspond to the holding members of the invention.

The first tube holder **1** and the second tube holder **2** are disposed in parallel with each other at a specific distance. The second tube holder **2** is fixed on a base **210** while the first tube holder **1** is slidably arranged to adjust the distance between itself and the second tube holder **2**. Between those holders **1**, **2** is disposed a wafer holder **140** constituting the cutting mechanism for moving a wafer **6** in an orthogonal direction with respect to the tubes **7**, **8** held in the first and second tube holders **1**, **2**.

A clamp rotor **30** for inverting the tubes cut with the wafer **6** is provided in the first tube holder **1**. FIG. **3** is a perspective view showing the clamp rotor **30**. FIG. **4** is a sectional view of a rotor piece **31(32)** of the clamp rotor **30** viewed from the direction indicated by an arrow A in FIG. **3**. It should be noted that the rotor pieces **31**, **32** correspond to the clamping members of the invention.

The clamp rotor **30** is constructed of a pair of rotor pieces **31**, **32** which are of semicircular shapes in rotational symmetry as if a gear is divided into halves. Thus, each of the rotor pieces **31**, **32** is of a similar semicircular shape. When the half-divided surfaces of the rotor pieces **31**, **32** are made contact with each other, one clamp rotor **30** is formed. More particularly, the clamp rotor **30** is constructed of centrally located tube holding portions **33**, **33** for holding the tubes, flange portions **34**, **34** protruding outward in a radial direction from the tube holding portions **33**, **33**, rim portions **35**, **35** formed perpendicularly at outer peripheries of the flange portions **34**, **34**. On the rim portions **35** are formed rotor gears **36**, **36** as well as two pairs of locking grooves **37***a*, **37***b*.

The tube holding portions **33** are constructed of holding grooves **33***a* and closing portions **33***b* formed by tapering a cylindrical portion toward the center axis to provide a tip end portion with a narrower width. Each of the holding grooves **33***a* is of a substantially semicircular section having a depth corresponding to approximately the outside diameter of the tube **7**(**8**). The closing portions **33***b*, **33***b* are arranged in mutually symmetrical relation to provide sufficient clearance to squeeze the two tubes set one on top of the other therein into flat shapes, thereby to firmly close the interior of the tubes.

The locking grooves **37***a*, **37***a* and the other locking grooves **37***b*, **37***b* are formed on the rim portions **35**, **35** in identical positions of the rotor pieces **31**, **32**. This is for corresponding the locking grooves **37***a*, **37***a* to a locking mechanism of the fixed clamp **11** and for corresponding the locking grooves **37***b*, **37***b* to a locking mechanism of the movable clamp **12**. This locking mechanism will be mentioned later. Each of the locking grooves **37***a*, **37***b* has a predetermined width defined by two protruding walls formed on the rim portion **35**.

The fixed clamp **11** and the movable clamp **12** of the first tube holder **1** in which the rotor pieces **31**, **32** are mounted will next be explained.

The fixed clamp **11** is constructed of a fixed clamp body **13** shown in FIG. **5** and a body cover **14** (see FIG. **1**) secured to the body **13**. The fixed clamp body **13** has an outer frame **16** formed protruding on a lateral wall **15** as illustrated, and the body cover **14** is screwed to this outer frame **16**. The fixed clamp **11** is thus of a hollow shape which is open in the upper surface, in which the above-described rotor piece **31(32)** is mounted. A stepping motor **3** (see FIG. **2**) is further attached to the body cover **14**. In association therewith, a row of gears is provided within the fixed clamp **11** for transmitting rotational output of the stepping motor **3** to the rotor piece **31(32)**.

The fixed clamp body **13** is formed with a single supporting bracket **17** and a forked supporting bracket **18** at both upper corner portions thereof as shown in FIG. **5**. The single supporting bracket **17** is provided for a pin-joint with the movable clamp **12**. A bearing **28** is pivotally mounted between the forked supporting bracket **18**.

A rotation supporting groove **19** that is a semicircular cutout for supporting the tube holding portion **33** of the rotor piece **31(32)** is formed at an upper side of the lateral wall **15**

of the fixed clamp body **13** and an upper side of the body cover **14** (not shown). Rollers **20** for rotationally supporting the rotor piece **31(32)** are pivotally mounted on the lateral wall **15** on a concentric circle with the rotation supporting groove **19**. The three rollers **20** are arranged such that two side rollers **20** are symmetrically disposed with respect to a central roller **20** at intervals of 60°.

A positioning projection **21** is provided to the fixed clamp body **13** as to protrude from the upper side of the lateral wall **15**.

The fixed clamp body **13** is, as mentioned above, configured such that the first tube holder **1** is disposed parallel to and movable with respect to the second tube holder **2**. FIG. **6** is a plan view of the fixed clamp body **13**.

The fixed clamp body **13** is provided with a slide tube **22** formed on the lateral wall **15** as to protrude perpendicularly thereto and a guide roller **23** supported rotatably in a direction along an axis of the slide tube **22**. The slide tube **22** is fitted on a protruding guide rod provided in the second tube holder **2**, which will be mentioned later. The guide roller **23** is disposed within a guide groove **29***a* of a guide block **29** fixed to the base **210** as shown in FIG. **1**.

In this manner, the fixed clamp **11** of the first tube holder **1** is attached such that the fixed clamp body **13** is supported above and out of contact with the base **210** by the slide tube **22** and the guide roller **23**.

The fixed clamp body **13** is further provided with a pressing arm **24** formed protruding toward the second tube holder **2** side as shown in FIG. **6**. At the tip end of the arm **24**, a roller bearing **25** is pivotally supported.

The fixed clamp **11** movably supported with the slide tube **22** and the guide roller **23** is always urged to the second tube holder **2** side by a spring **131** arranged between the fixed clamp **11** and a supporting wall **181** fixed onto the base **210** as shown in FIG. **1**.

Thus, the roller bearing **25** provided at the tip end of the pressing arm **24** is always brought into contact with a driving cam within the second tube holder **2** (described later) so that the bearing **25** rolls along a cam surface of the driving cam.

A tube guide **40** (see FIG. **1**) for accurately setting the tubes is fixed to the body cover **14** of the fixed clamp **11**. FIG. **7** is a perspective view of the tube guide **40** showing the side which is in contact with the body cover **14**.

The tube guide **40** is constructed of a guide body **41**, a pair of guide claws **42,42**, and springs **43,43** disposed respectively outside of the claws **42,42** so as to urge them inwards (toward each other).

Specifically, a warped groove **41***a* is formed in the center of the guide body **41** on which the tubes are set. The guide claws **42, 42**, attached to the guide body **41** and arranged on both sides of the groove **41***a*, are urged to the groove **41** a side by the springs **43, 43**. The guide claws **42, 42** are thus urged in directions of moving toward each other. These guide claws **42, 42** are movable in the urging directions. It should be noted that the pair of guide claws **42, 42** are identical in configuration and disposed such that one faces the front while the other one is reversed, whereby they may be used on either side, thus enabling the use of common parts.

Next, FIG. **8** is a perspective exploded view of the movable clamp **12** of the first tube holder **1** seen from the second tube holder **2** side. The movable clamp **12** is constructed of a movable clamp body **51** and a body cover **52** attached to the body **51**, thus becoming hollow, similarly to the fixing clamp **11**, and the rotor piece **31 (32)** is mounted therein.

Rotationally supporting grooves **53** and **54** that are semicircular cutouts are formed at corresponding positions of the movable clamp body **51** and the body cover **52**. Rollers **55** for rotationally supporting the rotor piece **31(32)** are pivotally mounted on the body cover **52** on a concentric circle with the rotationally supporting groove **54**. The three rollers **55** are arranged such that two side rollers **55, 55** are symmetrically disposed with respect to a central roller **55** at intervals of 60°. Furthermore, forked supporting brackets **56, 57** for pin joints are provided protruding at both ends of the movable clamp body **51**.

Next, FIG. **9** is a sectional view of the first tube holder **1**. More particularly, this is a schematic view showing the fixed clamp **11** with the fixed clamp body **13** from which the body cover **14** is removed and the movable clamp **12** with the clamp body **51** illustrated in section.

The first tube holder **1** is assembled by pin-joining the fixed clamp **11** to the movable clamp **12** by the respective supporting brackets **17, 56**. The movable clamp **12** thus can be oscillated or turned about the pin joining the brackets **17** and **56** so that an oscillation end of the body **51** moves into contact with the fixed clamp **11** (a closed position of the movable clamp **12**) or away from the fixed clamp **11** (an open position) as illustrated in FIG. **1**. A buckle **125** (see FIG. **8**) is pin-joined to the supporting bracket **57** formed at the oscillation end of the body **51** of the movable clamp **12**. The buckle **125** is configured such that a jaw portion **127** may be hooked over the bearing **28** of the fixed clamp **11** and be locked in the state shown in FIG. **9**.

In the clamping condition of the first tube holder **1** shown in FIG. **9**, the set tubes **7, 8** (see FIG. **2**) are held one over the other in the holding grooves **33***a*, **33***a* of the rotor pieces **31, 32** so that they are symmetrically clamped and closed by the closing portions **33***b*, **33***b* as illustrated. It is to be noted that the clamp rotor **30** in FIG. **9** is illustrated in a section along the line **B—B** of the rotor pieces **31, 32** shown in FIG. **4**.

The rotor pieces **31, 32** are mounted in the movable clamp **12** and the fixed clamp **11** respectively so that the three rollers **55** and the three rollers **20** are inserted between the tube holding portions **33** and the rim portions **35**. In the clamping condition as illustrated, the rotor pieces **31, 32** form one clamp rotor **30** (see FIG. **3**), and the rollers **20, 55** are located at equal intervals (intervals of 60°) on a concentric circle. The clamp rotor **30** is placed with the closing portions **33***b*, **33***b* protruding to the second tube holder **2** side.

The fixed clamp **11** is configured such that the stepping motor **3** (see FIG. **2**) is fixed to the body cover **14**, a driving gear **61** is attached to a motor shaft **3***a* of the motor **3**, the shaft **3***a* being inserted through a through hole **32***a* (see FIG. **1**) into the interior of the fixed clamp **11**. The driving gear **61** is in mesh with an access gear **62** and a drive gear **63**, and the driving gear **63**, in turn, is in mesh with the rotor gear **36** of the clamp rotor **30**.

The fixed clamp **11** and the movable clamp **12** are provided with locking mechanisms, serving as rotation preventing means, for supporting the rotor pieces **31** and **32** in position within the corresponding clamps **11** and **12** in order to prevent displacement of the rotor pieces **31** and **32** from the positions shown in FIG. **9** while no tube is set or the tubes set therein are not clamped. Each of the locking mechanism is arranged to fit into the locking groove **37***a* or **37***b* provided in the rotor pieces **31, 32** for limiting displacement, or misalignment, of the rotor pieces **31, 32**.

The locking mechanism on the fixed clamp **11** side will first be explained. This locking mechanism is constructed of

a slide plate **65** which is an engaging slider, a crank plate **66**, and a spring **67** as illustrated in FIG. **9**. In the slide plate **65** are formed two circular slide holes **65***a*, **65***b* extending lengthwise of the plate and located in parallel with each other. The slide plate **65** is slidably supported by engaging the holes **65***a*, **65***b* with pins **68***a*, **68***b* formed projecting on the lateral wall **15** of the fixed clamp body **13**.

The slide plate **65** is formed with an engaging portion **65***p* at a tip end thereof, protruding in a longitudinal direction of the slide holes **65***a*, **65***b*, and a hook portion **65***q* at the other end thereof, bent almost perpendicularly from the plate surface. The slide plate **65** is always urged toward the center of the clamp rotor **30** by a spring **67** anchored at one end to the pin **68***a* and at the other end to the hook portion **65***q*.

On the other hand, the crank plate **66** serving a lever is rotatably supported at substantially a central portion thereof about the pin **68***b* so that one end (lower end) having a straight linear shape is made into contact with an abutment surface of the hook portion **65***q* of the slide plate **65**, the surface being inside in an urging direction, while the other end (upper end) having an L-shaped configuration is disposed to be insertable in a window portion **26** formed in the fixed clamp body **13**.

The locking mechanism on the movable clamp **12** side is constructed of a flat spring **71** having a U-shaped configuration and an engaging piece **72** fixed on the spring **71**. This flat spring **71** is a resilient member of the invention. The engaging piece **72** has an engaging protrusion insertable in the locking groove **37** of the clamp rotor **30**. The flat spring **71** is formed, at one end, with a supporting ring **71***a* which is anchored to a pin **58** formed projecting from an inside wall of the movable clamp body **51**. The other end of the flat spring **71** is abutted against an inside wall of the movable clamp body **51** so that the inside wall receives the urging force of the flat spring **71**. At this time, the engaging piece **72** is urged toward the center of the clamp rotor **30** by the flat spring **71**.

The locking grooves **37***a*, **37***b* respectively formed in the rotor pieces **31**, **32** are arranged to face the engaging portion **65***p* and the engaging piece **72** in a clamping condition as indicated in FIG. **9**, thereby uniquely positioning the rotor pieces **31**, **32**. Each of the locking grooves **37***a*, **37***b* is defined by inner opposite parallel surfaces of the two protruding walls. In association therewith, the engaging portion **65***p* and the engaging piece **72** which are inserted into those grooves are formed in a square protruding shape corresponding to the groove shape.

The second tube holder **2** will be next explained in detail. FIG. **10** is an external perspective view of a fixing clamp **81** of the second tube holder **2** viewed from the first tube holder **1** side. FIG. **11** is a perspective view showing a fixed clamp body of the second tube holder **2**.

This fixed clamp **81** is constructed of a hollow fixed clamp body **83**, similar to the first tube holder **1**, and a body cover **84** covering the hollow body **83** from the exterior. This body **83** is configured such that an outer frame **86** as illustrated is perpendicularly provided to a lateral wall **85** and the body cover **84** is fixed to this outer frame **86** by screws.

The fixed clamp body **83** is formed with a single supporting bracket **87** and a forked supporting bracket **88**, respectively, at both upper corner portions thereof. The single supporting bracket **87** is provided for a pin joint with the movable clamp **82**, while a bearing **90** is pivotally supported between the forked supporting bracket **88**. A positioning protrusion **89** is formed in the fixed clamp body **83** as to protrude upward from an upper side of the lateral wall **85** as shown in FIG. **10**.

The fixed clamp body **83** is, as shown in FIG. **10**, provided with a guide rod **91** formed perpendicular to the lateral wall **85** for supporting the slide tube **22** (see FIG. **5**) of the first tube holder **1**. The lateral wall **85** is largely cutout for exposing an internally provided driving cam **92** to the exterior.

The driving cam **92** is formed integrally with a reduction gear **95** and is pivotally mounted within the fixed clamp body **83** in the illustrated position. The driving cam **92** is constituted of a circular shaped slide cam **93** and an eccentric shaped cutting cam **94** that are integrally formed. The slide cam **93** is formed, on the end face, with a slide cam surface **93***a* with a slope for changing a height of the cam **93** in the axial direction. The cutting cam **94** is formed, on the outer periphery, with an eccentric cam surface **94***a*.

On the other hand, the stepping motor **4** (see FIG. **2**) is fixed to the body cover **84**, as shown in FIG. **10**. A driving gear **96** is attached to a motor shaft **4***a* of the motor **4**, the shaft **4***a* being inserted into the interior of the body **83** through a through hole **84***a*. The driving gear **96** is in mesh with the reduction gear **95**.

A tube guide **100** is provided in the fixed clamp body **83** as shown in FIG. **11**. The tube guide **100** is constructed of a pair of guide claws **101**, **101** serving as supporting means for supporting tubes set therein. These guide claws **101**, **101** are disposed penetrating the outer frame **86** forming an upper surface of the body **83** to protrude upward. These guide claws **101** are integrally formed with a plunger case **102** disposed inside the fixed clamp body **83**.

Projections **101***a*, **101***a* are formed in the guide claws **101**, **101** at respective tip end portions, projecting inwards, for preventing the tubes set in the guide **100** from coming off. A holding groove **103** provided between the guide claws **101**, **101** is continuous to and flush with a holding groove **98** formed in the fixed clamp body **83**. On the other hand, the plunger case **102** is a housing in which a stepped plunger **104** is disposed slidably in a vertical direction. The housing is open in the bottom and fixedly mounted on a supporting plate **99** formed protruding inwards from the lateral wall **85** in the fixed clamp body **83**.

The plunger **104** is urged upward by a spring **105** arranged between the plunger **104** and the supporting plate **99** so that a tip end of the plunger **104** penetrates to protrude from a bottom surface of the holding groove **103** of the tube guide **100**. The plunger **104** is also provided with a magnet **106** embedded in a lowermost step portion thereof such that a position of this magnet **106**, that is, the height of the plunger **104** may be detected by a tube holding detecting sensor (not shown) fixed in the body cover **84**. The presence or absence of a tube within the holding groove **103** is determined upon detection of the height of the plunger **104**.

An O-ring **107** is fitted to the plunger **104** for preventing dialysis liquid from flowing into the plunger case **102** in case the liquid leaking from cut tubes should enter the through hole formed in the bottom surface of the holding groove **103**.

FIG. **12** is a perspective view showing a fixed clamp **82** and a buckle **120**. The movable clamp **82** is constructed of an integrally-molded hollow clamp body **110** both ends of which are formed with forked supporting brackets **111**, **112**. This clamp body **110** is provided with a U-shaped groove **113** for passing a tube through, a closing portion **114** formed protruding in a lateral direction, a pressing portion **115** between the groove **113** and the closing portion **114**. The pressing portion **115** is protruded as to slightly press the tube. The movable clamp body **110** is further formed with an engaging wall **116** which is disposed closer to an oscillation

end side of the body **110** (the buckle **120** side) and will be made into contact with the positioning protrusion **89** of the fixed clamp body **83**.

The buckle **120** is pin-joined to the supporting bracket **112** of the movable clamp body **110**. The buckle **120** is of a configuration which can be integrally assembled with the buckle **125** of the first tube holder **1** shown in FIG. **8**. Specifically, a grasping plate **121** of the buckle **120** is largely projecting to one side (the first tune holding holder **1** side) at which a groove **122** is formed for allowing an inserting portion **126** and a pin **129** of the buckle **125** to be inserted therein. Furthermore, the buckle **120** is formed with a jaw portion **123** and a pressing protruding piece **124**, similarly to the buckle **125**, at a position corresponding to the supporting bracket **112**.

As illustrated in FIG. **11**, the second tube holder **2** is assembled by pin-joining the movable clamp **82** to the fixed clamp body **83** by the supporting brackets **87**, **111**. The movable clamp **82** can be oscillated or turned about the pin joining the brackets **87**, **111** so that an oscillation end (the buckle **120** side) moves into contact with the fixed clamp **81** (a closed position of the movable clamp **82**) or away from the fixed clamp **81** (an open position) as shown in FIG. **11**.

On the other hand, the jaw **123** of the buckle **120** pin-joined to the oscillation end of the body **110** of the movable clamp **82** is hooked over a bearing **90** and is locked in a clamping condition as illustrated in FIG. **11**.

In the clamping condition of the second tube holder **2** shown in FIG. **11**, the holding groove **98** of the fixed clamp body **83** and the closing portion **114** of the movable clamp body **110** are arranged to have a clearance therebetween sufficient to squeeze the tubes **7**,**8** set therein one over the other into flat shapes, thereby to close the interior of the tubes.

The first tube holder **1** and the second tube holder **2** constructed as above are disposed on the base **210** in parallel with each other, as shown in FIGS. **1** and **2**. More particularly, the fixed clamp body **83** of the second tube holder **2** is directly fixed onto the base **210** and the slide tube **22** of the first tube holder **1** is slid on the guide rod **91** formed in the fixed clamp body **83** of the second tube holder **2** (see FIG. **10**). At this time, both the fixed clamps **11**, **81** are parallel to each other. Since the other end of the fixed clamp **11** (opposite to the slide tube **22** side) is also supported by the guide roller **23**, the first tube holder **1** is enabled to move as to adjust a distance between itself and the second tube holder **2** while maintaining a parallel relation to the second tube holder **2** and to the base **210**.

In the first tube holder **1** movably supported in parallel relation to the second tube holder **2** as mentioned above, the fixed clamp body **13** is always urged toward the second tube holder **2** side by the spring **131**. With this arrangement, the roller bearing **25** of the pressing arm **24** protruding from the first tube holder **1** (see FIG. **6**) is made into contact with the slide cam **93** of the driving cam **92** provided in the second tube holder **2**. The roller bearing **25** is allowed to always roll along the cam surface of the slide cam **93**.

As shown in FIG. **13**, the first tube holder **1** and the second tube holder **2** are arranged to have a slight space between two closing portions, that is, the position of the holding grooves **33***a*, **33***a* of the rotor piece **31**(**32**) and the position the closing portion **114** of the movable clamp **82** at the tip end of the holding groove **98** of the fixed clamp **81**. FIG. **13** is a front view of the first tube holder **1** and the second tube holder **2** viewed from the direction indicated by an arrow C in FIG. **1**.

Here, the holding groove **98** of the fixed clamp body **83** has a bottom surface flush with a height of the closing portion **33***b* of the rotor piece **31** (**32**) located on a lower side so as to correspond with the height of the tubes **7**, **8** grasped and closed by the clamping rotor **30**.

Therefore, the tubes **7**, **8** are squeezed symmetrically with respect to an intermediate point of respective center axes of the tubes **7**, **8** (i.e., a contact line of both tubes **7**, **8**) in the clamp rotor **30** side, while the tubes **7**, **8** are squeezed to the bottom surface side of the holding groove **98** in the fixed clamp body **83** side as shown in FIG. **13**.

A cutting mechanism is further provided between the first tube holder **1** and the second tube holder **2** for vertically moving the wafer **6** for cutting the tubes **7**, **8** squeezed and held in the holders **1**, **2**.

This cutting mechanism will be explained below. A wafer holder **140** for holding and vertically moving the wafer **6** is disposed between the above-described first and second tube holders **1** and **2**. FIGS. **14** and **15** are perspective views showing the wafer holder **140** for holding the wafer **6**. More particularly, FIG. **14** is a view of the holder **140** seen from the first tube holder **1** side and FIG. **15** a view of the same seen from the second tube holder **2** side.

The wafer holder **140** is supported so as to be able to oscillate or rotate about the guide rod **91** of the second tube holder **2**, and is constructed of a base plate **141** provided with an oscillation tube **142** which is slid onto the guide rod **91**, a fixed plate **143** and an opening/closing plate **145** which are provided on both sides of the base plate **141**. The fixed plate **143** is fixed to the base plate **141** on the first tube holder **1** side, and a groove (not shown) is formed between the plates to allow the wafer **6** to pass through. The fixed plate **143** is provided with two stop portions **143***a*, **143***b* extending upward with turned ends for preventing an upward displacement of the wafer **6**.

The opening/closing plate **145** is supported rotatably about a shaft provided at a lower portion with respect to the base plate **141**. When a lower portion of the plate **145** below the shaft-supported portion is urged by an urging member, the plate **145** is rotated to move an upper portion away from the fixed plate **143**, or to an open position. Upon release of the urging force, to the contrary, the plate **145** is rotated to move the upper portion into contact with the fixed plate **143**, or to a closed position.

On the opening/closing plate **145** are arranged electrodes **146***a*, **146***b* at a position corresponding to the stop portions **143***a* of the fixed plate **143**. When the electrodes **146***a*, **146***a* come into contact with a resistor terminal of the wafer **6** loaded in the wafer holder **140**, electricity is supplied to the resistor through the electrodes **146***a*, **146***a*. A pressing piece **145***b* is formed in the opening/closing plate **145** as to face the stop portion **143***b* of the fixing plate **143**. A single linear projection **145***s* is further formed in an outer surface of the opening/closing plate **145** in parallel to a transferring direction of the wafer **6**.

To the base plate **141** are provided positioning flat springs **147***a*, **147***b*, **147***c* for positioning the wafer **6** by pressing the same against the fixing plate **143**, and a retraction-preventing flat spring **148** disposed in overlapping relation to the rearmost flat spring **147***a*. The positioning flat springs **147***a*, **147***b*, **147***c* are disposed as to press the wafer **6** at three points transversely aligned in almost the center of the height of the wafer **6** loaded in the wafer holder **140**. The retraction-preventing flat spring **148** is formed with a turned end **148***a* for interrupting a retraction path of the wafer **6** that has already passed the spring **148**.

For appropriately performing cutting and connecting of tubes, the wafer **6** is required to move in an orthogonal direction to tubes **7, 8** held in the first tube holder **1** and the second tube holder **2**. For that purpose, the wafer holder **140** needs to be oscillated along an orthogonal surface without deflecting or wobbling. In the present embodiment, the lateral wall **85** of the fixed clamp body **83** directly fixed to the base **210** (see FIG. **10**) is used as a reference surface so that the wafer holder **140** is slid along the reference surface to be oscillated.

In the wafer holder **140**, an end surface **142**A of the oscillation tube **142**, an end surface **151**A of an attaching block **151** to which the positioning flat spring **147***c* is attached, and an end surface **152**A of a sliding tube **152** fixed at a tip end of the base plate **141** are arranged flush with each other.

The wafer holder **140** is then fitted on the guide rod **91** of the second tube holder **2** together with the first tube holder **1** and is urged to the second tube holder **2** side by a spring **153** disposed the holder **140** and the first tube holder **1** (see FIG. **2**). With this arrangement, each of the end surfaces **142**A, **151**A, **152**A of the wafer holder **140** are continuously pressed against the lateral wall **85** of the fixed clamp body **83** serving as a reference surface. In this state, the wafer **6** loaded in the wafer holder **140** is orthogonal with respect to the tubes **7, 8**.

The wafer holder **140** is also provided with a roller bearing **155** that is pivotally mounted on a shaft fixed to the base plate **141** on the surfaces **142**A, **151**A, **152**A side. Though not shown in the drawings, the wafer holder **140** is attached in a state where the roller bearing **155** is inserted in the fixed clamp body **83** (see FIG. **10**) and is put on a peak portion of the eccentric cam surface **94***a* of the cutting cam **94** of the driving cam **92**.

The wafer transferring mechanism for transferring the wafer **6** into the wafer holder **140** will next be explained. A plurality of the wafers **6** are accommodated in a stacked state in a wafer cassette **160** as shown in FIGS. **1** and **2**. Of those accommodated wafers, a wafer **6** is pushed out onto a transferring line and is transferred in a direction as indicated by the arrow X by means of a transfer top **161** which moves along the transferring line (see FIG. **2**).

The transfer top **161** is formed, at a tip end, with a stepped claw portion **161***a* corresponding to the thickness of the wafer **6**. The transfer top **161** is integrally formed with a slider **162**. This slider **162** is slidably supported on a guide rod **171** fixed to between supporting walls **181, 182** fixed on the base **210**.

Furthermore, a male screw **172** is fixed to between the supporting walls **181** and **182** in parallel with the guide rod **171**. A female screw holding ball (namely, a ball thread arrangement) is provided in a female screw block **163** integrally formed with the slider **162**. This female screw is engaged with the male screw **172** to constitute a ball screw.

A transmission gear **173** is fixed to the male screw **172** at an end on the supporting wall **182** side. A stepping motor **5** is fixed to the supporting wall **182** from outside with a motor shaft going inward through the supporting wall **182**. A driving gear **174** is fixed to the motor shaft of the stepping motor **5** and is engaged with the transmission gear **173**.

Markers **166, 167** which are two plates partially overlapped one over the other are attached on an upper surface of the female screw block **163**. On the other hand, a control substrate **183** is fixed to the supporting walls **181, 182** as illustrated in FIG. **2**. The control substrate **183** is provided with a standby-detecting sensor **185** and a transfer-detecting sensor **186**. The standby-detecting sensor **185** is a sensor for detecting a standby position of the transfer top **161** based on the position of the marker **166**. The transfer-detecting sensor **186** is a sensor for detecting a transferring position of the transfer top **161** based on the position of the marker **167**. The markers **166, 167** are pivotally supported on the female screw block **163** such that an opening degree between tip ends of the markers **166, 167**, serving as an object to be detected, may be adjusted.

Stoppers **175, 176** for preventing overrun of the slider **162** are fitted on the guide rod **171** and in contact with the supporting walls **181, 182**, respectively.

The slider **162** is also provided with a supporting arm **168** extending from below the transfer top **161** and a pin **169** protruding from a tip end of the supporting arm **168**. A prism-shaped beam **191** is fixed between the supporting wall **182** and the fixed clamp block **81** of the second tube holder **2** and in parallel with the guide rod **171**. The beam **191** is formed with a stepped corner constituting a rail **192**. A prism-shaped operating rod **195** is placed on the rail **192**. A guide groove **195***a* is formed in a rear surface of the operating rod **195** (i.e., a surface which is in contact with the rail **192**) along a longitudinal direction thereof. A protruding guide pin **193** formed in the rail **192** is inserted in the groove **195***a*.

The tip end of the supporting arm **168** formed extending from the slider **162** is brought into contact with a side surface of a rear end portion of the operating rod **195**, and the pin **169** provided at the tip end of the supporting arm **168** is loosely received in a bore formed in the operating rod **195**.

Tube connecting operations of the tube connecting apparatus of the above-described arrangement will be explained below. The tube connecting apparatus is entirely covered by a cover (not shown) such that upper portions of the fixed clamps **11, 81** and the movable clamps **12, 82** are exposed to the exterior. Therefore, by opening the movable clamps **12, 82** upward as illustrated in FIG. **1**, the upper surfaces of the fixed clamps **11, 81** will appear to enable setting of tubes **7, 8**. Thus, a user sets two tubes **7, 8** (see FIG. **2**) one over the other in the tube guides **40, 100**. At this time, the tubes **7, 8** are placed with their central axes being parallel one over the other. This is because the distance between the guide claws **42, 42** of the tube guide **40** (see FIG. **7**) and that between the guide claws **101, 101** of the tube guide **100** (see FIG. **11**) are adjusted to the outer diameter of the tube **7** (**8**).

The tubes **7, 8** once set in the tube guide **100** are prevented from coming off the holding groove **103** by the protrusions **101***a*, **101***a* of the guide claws **101, 101**. The tubes thus press down the plunger **104** protruding through the bottom surface of the holding groove **103** owing to their elastic force (see FIG. **11**).

When the plunger **104** is pushed downward by the tubes against the urging force of the spring **105**, the movement of the magnet **106** is detected by the sensor (not shown) and a corresponding signal is transmitted to a controller of the apparatus.

After setting the tubes **7, 8**, the user closes the movable clamps **12, 82** of the tube connecting apparatus in the condition shown in FIG. **1** by grasping the buckle **120**. Thus, the movable clamps **12, 82** are set on the fixed clamps **11, 81** to clamp the tubes **7, 8** held one on top of the other.

The buckle **120** being integrally assembled with the buckle **125** as described above, the user can simultaneously close both the movable clamps **12, 82** through operation by holding the grasping plate **121** (see FIG. **12**). Then, when the buckle **120** with the movable clamps **12, 82** being set on the

fixed clamps **11, 81** (see FIGS. **9** and **11**) is rotated, the jaw portions **123, 127** are hooked over the bearings **28, 90** of the fixed clamps **11, 81** into a locking state.

In association with operations of setting the tubes **7, 8** and locking through the buckle **120** by the user, the tube connecting apparatus performs tube set confirmation and lock releasing of the clamp rotor **30**.

When the user first locks the buckles **120, 125**, the pressing protruding piece **124** of the buckle **120** turns on a limit switch **201** illustrated in FIG. **11**. Then, this ON signal of the limit switch **201** is compared with a detecting signal detected based on the movement of the plunger **104** to confirm the presence or absence of the tubes **7, 8**.

If an ON signal of the limit switch **201** is input in a condition where the tubes **7, 8** are not set, the controller confirms a tube setting failure or the absence of tubes and indicates thereof by a sound or the like to the user. On the other hand, if an ON signal of the limit switch **201** is input with the tubes **7, 8** being set, the controller waits for a following signal representative of start of tube connection.

After the driving of the tube connecting apparatus is started, it is necessary to prevent the movable clamps **12, 82** from being erroneously opened. In case the movable clamps **12, 82** are erroneously opened, this would release clamping of the tubes **7, 8**, and thus the tubes cannot be held anymore.

Thus, a solenoid **202** shown in FIG. **10** is energized in response to the ON signal of the limit switch **201**, causing a plunger **203** to moved upward. With this arrangement, the plunger **203** is moved up into orbit in an opening direction of the pressing protruding piece **124** located as shown in FIG. **11** to prevent rotation of the buckle **120** itself, thereby preventing opening of the movable clamps **12, 82**.

Next, when the movable clamps **12, 82** are closed into contact with the fixed clamps **11, 81**, the positioning protrusions **21, 89** are inserted into the hollow movable clamps **12, 82** (see FIG. **9** and FIG. **1**) to be fitted therein with no clearance in a lateral direction (lengthwise of the tubes), preventing lateral misalignment. Thus, the movable clamps **12, 82** can be closed in accurate positions with respect to the fixed clamps **11, 81**. It is noted that the hollow portions of the movable clamps **12, 82** into which the positioning protrusions **21, 89** are inserted correspond to positioning holes of the invention.

At this time, in the first tube holder **1** side, the positioning protrusion **21** inserted in the movable clamp **12** comes into contact with the flat sprint **71**, then pushing the spring **71** to retract as shown in FIG. **9**. Thus, the flat spring **71** is warped and deformed by the pressing force of the positioning protrusion **21**, and the engaging piece **72** is accordingly retracted to be detached from the locking groove **37***b* of the clamp rotor **30**.

When the user then locks the buckle **125**, its pressing protruding piece **128** comes into contact with the end of the crank plate **66** projecting out from the window portion **26** of the fixed clamp **11** (represented by the broken line in FIG. **9**) to push inward the crank plate **66**. Consequently, the crank plate **66** is oscillated about the pin **68***b* being a fulcrum with the other end of the plate **66** pushing the hook portion **65***q* of the slide plate **65**. Accordingly, the slide plate **65** is slid against the urging force of the spring **67**, retracting the engaging portion **65***p* to be detached from the locking groove **37***a* of the clamp rotor **30**. As a result, the clamp rotor **30** (rotor pieces **31, 32**) is enabled to rotate.

After completion of proper clamping of the tubes **7, 8** as described above, the tube connecting apparatus enters a standby mode of waiting for a signal from a start switch. In this state, when the user then depresses the start switch, each of the mechanisms of the apparatus is driven to perform cutting and connecting of the tubes. At this time, the wafer **6** is first exchanged.

Such an exchange is performed because one wafer **6** is used for each tube connecting operation and the wafer **6** used in the last operation remains left within the wafer holder **40** (see FIG. **1**). Therefore, upon depression of the start switch, exchange of the wafer **6** is performed through the following actions (see FIG. **1** and FIG. **2**).

Upon depression of the start switch by the user, the stepping motor **5** is driven and the rotational force thereof is transmitted to the male screw **172** constituting the ball screw by means of the driving gear **174** and the transmission gear **173**. The male screw **172** is accordingly rotated, causing the female screw block **163** of the female screw engaging with the male screw **172** to move in the axial direction. At this time, the female screw block **163**, formed integrally with the slider **162** supported on the guide rod **171**, is prevented from rotating by the slider **162**. The driving of the stepping motor **5**, therefore, also allows the slider **162** to slide on the guide rod **171** in the axial direction in association with the movement of the block **163**, thus moving the transferring top **161** and the operating rod **195** in the same direction.

The stepped claw portion **161***a* of the tip end of the transfer top **161** is moved in the direction indicated by an arrow X in FIG. **2** and catches the rear end of a new wafer **6** to push the wafer **6** forward. At this time, a single wafer **6** is drawn out from the wafer cassette **160**. The wafer **6** pushed by the transfer top **161** is transferred in the direction X while keeping its upright state and is slid into the groove in the wafer holder **140**.

The movement of the slider **162** in the direction X not only makes the transfer top **161** transfer the wafer **6** but also makes the operating rod **195** perform opening and closing operations of the wafer holder **140**. Specifically, when the slider **162** is moved in the direction X, the operating rod **195** which is pin-supported by the tip end of the supporting arm **168** is similarly slid in the direction X on the rail **192**. At this time, the operating rod **195** can be moved straight forward without falling off from the rail **192** since the guide groove **195***a* is fitted on the guide pin **193** fixed on the rail **192**. A tip end of the operating rod **195** slid on the rail **192** in the direction X is inserted between the fixed clamp **81** of the second tube holder **2** and the wafer holder **140**. Since the operating rod **195** is synchronously moved with the movement of the transfer top **161** through the slider **162**, opening and closing of the wafer holder **140** by the operating rod **195** is performed in timed relation to insertion of the wafer **6** into the wafer holder **140**.

In the path of the operating rod **195** which is moved into between the fixed clamp **81** and the wafer holder **140** in synchronization with the transfer of the wafer **6** in the direction X, disposed is the linear projection **145**S of the opening/closing plate **145** of the wafer holder **140** (see FIG. **15**), as mentioned above. Accordingly, when the tip end of the rod **195** moving forward comes into contact with an end portion of the linear projection **145**S. However, both the tip end of the operating rod **195** and the end portion of the linear projection **145**S are tapered to prevent the operating rod **195** from abutting against the end portion of the linear projection **145**S. Thus, the rod **195** can be smoothly moved forward along the linear projection **145**S while laterally pressing the opening/closing plate **145**. In association therewith, a lower portion of the plate **145** including the linear projection **145**S is pushed toward the fixing plate **143** side, while an upper

portion of the plate **145** including the pressing piece **145***b* is separated from the fixed plate **143**. The plate **145** is turned in this manner into an open state. Thereafter, the lower portion of the plate **145** remains pushed by the operating rod **195** sliding forward along the linear projection **145S**, maintaining the open state of the plate **145**.

Then, the wafer **6** is transferred into the wafer holder **140** in timed relation to the opening movement of the opening/closing plate **145**. This plate **145** is held in the open state until the wafer **6** is completely placed in a specified position.

The position of the wafer **6** loaded in the wafer holder **140** is adjusted by a stop position of the transfer top **161**. In conjunction with the transfer top **161**, as shown in FIG. **2**, the marker **167** is moved and then detected by the transfer-detecting sensor **186**. Specifically, the position of the transfer top **161** at which the marker **167** moved together with the top **161** is detected by the sensor **186** is the specified position of the wafer **6** within the wafer holder **140**.

Thus, when the marker **167** is moved in the direction X together with the transfer top **161** and is detected by the detecting sensor **186**, a detection signal from the sensor **186** is transmitted to the controller. Upon receipt of the detection signal, the controller causes the stepping motor **5** to rotate in a reverse direction.

The reverse rotation of the motor **5** causes reverse rotation of the male screw **172** to move the female screw block **163** and the slider **162** in the direction opposite to the direction X. The transfer top **161** is then retracted, while only the wafer **6** is left in the wafer holder **140**.

When the transfer top **161** is returned to the position as illustrated in FIG. **2**, the standby-detecting sensor **185** detects the marker **166** and transmits a signal indicative thereof to the controller to cause the stepping motor **5** to stop rotation.

As above, the moving positions of the slider **162** and others are detected by the standby-detecting sensor **185** and the transfer-detecting sensor **186** and controlled based on the detection results of the sensors. The specified position of the wafer **6** or the standby positions of the slider **162** and others may be finely adjusted by changing inclinations of the markers **166**, **167** with respect to the sensors **185**, **186** fixed to the control substrate **183**.

Returning to the time of loading of the wafer **6** into the wafer holder **140** (see FIGS. **14** and **15**), the wafer **6** pushed by the transfer top **161** is slid into the groove formed between the base plate **141** and the fixed plate **143**. In positions in the path of the wafer **6** are arranged the positioning flat springs **147***a*, **147***b*, and **147***c* pressed against the fixing plate **143** by the urging force. Thus, the wafer **6** is moved forward while pressed into contact with the fixing plate **143** by the springs **147***a*–**147***c* to the specified position mentioned above.

On the other hand, the wafer **6** used in the last operation remains loaded in the wafer holder **140**. This older wafer **6** is also pressed against the fixing plate **143** by the springs **147***a*, **147***b*, and **147***c*. Therefore, end faces of wafers **6**, **6** (i.e., the rear end of the older one and the front end of the new one) are surely butted against each other in spite of their very thin thicknesses of several hundreds of μm, so that the older wafer **6** is pushed out from the wafer holder **140** by the new wafer **6**. Thus, exchange of the wafers **6** can be reliably performed.

When the wafer **6** is transferred to the specified position in the wafer holder **140**, the rear end of the wafer **6** having passed the retraction preventing flat spring **148**, the tip end of this spring **148** is pressed into contact with the fixed plate **143**, so that the turned end **148***a* of the tip end interrupts the retracting path of the wafer **6**. Accordingly, in cases where the user attempts to take the older wafer **6** which has been pushed out from the holder **140**, even if the newly loaded wafer **6** is erroneously pushed by the older wafer **6**, the new wafer **6** is prevented from moving back by the turned end **148***a* of the spring **148** and thus can be held in the specified position.

When the operating rod **195** is retracted together with the slider **162** in the above-described manner, the opening/closing plate **145** is released from the pressing by the rod **195** and turned back from the open state to the closed state by the urging members (not shown). Then, the electrodes **146***a*, **146***b* disposed on the opening/closing plate **145** come into contact with the terminal of the resistor of the wafer **6**, energizing the resistor to raise the temperature of the wafer **6**, for example, up to approximately 300° C. in the present embodiment.

When the temperature of the wafer **6** is sufficiently raised, cutting of the tubes **7**, **8** may be performed. This cutting operation is performed by oscillating (rotating) the wafer holder **140** to move up the wafer **6** in an orthogonal direction to the tubes **7**, **8** clamped by the first tube holder **1** and the second tube holder **2**. The oscillation of the wafer holder **140** are caused by transmitting rotation of the stepping motor **4** (see FIG. **2**) to the driving cam **92** (see FIG. **10**).

Specifically, when the stepping motor **4** is actuated, its rotational output is transmitted through the driving gear **96** fixed to the motor shaft **4***a* to the reduction gear **95**, causing the driving cam **92** integrally formed with the reduction gear **95** to rotate. As the driving cam **92** is rotated, a height of the peak portion of the cutting cam **94** on which the roller bearing **155** of the wafer holder **140** is put is varied. Accordingly, the wafer holder **140** is oscillated up and down through the roller bearing **155** raised and lowered in relation to the rotation of the cam **92**.

As shown in FIG. **2**, the end surface of the oscillation tube **142** of the wafer holder **140** is pressed against the fixed clamp **81** by the spring **153**. Therefore, the end surface **151A** of the attaching block **151** and the end surface **152A** of the sliding tube **152**, both of the end surfaces **151A** and **152A** being flush with the end surface **142A** of the oscillation tube **142**, make contact with the lateral wall **85** (a reference surface) of the fixed clamp **81**.

By rotation of the driving cam **92**, as mentioned above, upward oscillating (rotating) movement of the wafer holder **140** about the oscillation tube **142** is performed. At this time, the end surface **142A** is rotated about the guide rod **91** in contact with the lateral wall **85** of the fixed clamp **81** (see FIG. **10**), while the end surfaces **151A** and **152A** are slid along the lateral wall **85**. Thus, the wafer holder **140** can be oscillated up along the lateral wall **85** without deflecting or wobbling, allowing the wafer **6** to move in an orthogonal direction with respect to the tubes **7**, **8**. It should be noted that slide tapes (not shown) for restricting sliding resistance are adhered to sliding area of the lateral wall **85** (a reference surface) corresponding to the end surfaces **142A**, **151A**, and **152A**, thereby enabling smooth oscillating movements of the wafer holder **140**.

The heated wafer **6** loaded in the wafer holder **140** when moved up as above comes into contact from below with the tubes **7**, **8** clamped by the first and second tube holders **1** and **2**, thus melting the portions of the tubes contacting with the wafer **6** to cut the tubes.

FIG. **16** is a view showing positions of the wafer **6** in cutting the tubes **7**, **8**.

A cutting side (upper side) of the heated wafer **6** is brought into contact with the tubes **7, 8** from below (as indicated by a dotted line in FIG. **16**) and then is slid obliquely by the oscillation wafer holder **140** to accordingly cut the tubes **7, 8** (as indicated by a solid line in FIG. **16**). Accordingly, the contact portion of the cutting edge of the wafer **6** with the tubes **7, 8** is gradually shifted in the course of cutting, the wafer **6** can retain an amount of heat of the contact portion whereby to melt and cut the tubes.

The retaining of the heat amount of the wafer **6** is required for the following reason. The cut end faces of the tubes **7, 8** need to be sufficiently melted to be welded after cutting. On the other hand, the wafer **6** will lose heat to the tubes **7, 8** during melting to cut them. The wafer **6** in itself is thin and has substantially no heat storage ability. When the wafer **6** cuts the tubes by using only one portion of the cutting edge, the temperature of this portion is remarkably decreased, disabling the wafer **6** in contact with the cut end faces to sufficiently melt them. As mentioned above, the obliquely sliding of the cutting edge of the wafer **6** with respect to the tubes **7, 8** can gradually shift the cutting portions so that the temperature thereof may be kept above a constant temperature sufficient to melt the cut end faces of the tubes. Thus the cut end faces of the tubes can be sufficiently melted for connection.

The cutting and welding of the tubes **7, 8** by the wafer **6** is performed at the closed portions of the tubes **7, 8** squeezed by the first tube holder **1** and the second tube holder **2** (see FIG. **13**).

When the movable clamps **12, 82** are set on the fixed clamps **11, 81**, the tubes **7, 8** held in the tube guide **40, 100** are clamped as shown in FIG. **1** by means of the closing portions **33***a*, **33***b* of the clamp rotor **30** (see FIG. **3**) in the first tube holder **1** and by means of the holding groove **98** of the fixed clamp body **83** (see FIG. **10**) as well as the closing portion **114** of the movable clamp body **110** (see FIG. **12**) in the second tube holder **2**. Therefore, the tubes **7, 8** appearing between the first and second tube holders **1** and **2** are flattened with the interiors tightly closed. The flattened portions in question are to be cut by the wafer **6** and then to be welded.

Hence, the wafer **6** is obliquely moved up as above by the oscillating movement of the wafer holder **140** to cut the tubes **7, 8** as shown in FIG. **16**. The tubes **7, 8** have been clamped and squeezed in advance such that liquid in the tubes is pushed away from the cutting portions at clamping, preventing liquid leakage when the tubes **7, 8** are cut.

At the time of cutting the tubes, the cut ends of the tubes **7, 8** are hot in a condition of melted or softened resin, and therefore are in contact in an airtight manner with the wafer **6**. Therefore, the interiors of the tubes **7, 8** are prevented from being exposed to the atmosphere and maintained in an aseptic condition until the connecting of the cut ends of the tubes is performed subsequently to the cutting.

Next, of the tubes **7, 8** which have been cut apart by the wafer **6**, the cut portions clamped by the first tube holder **1** are inverted by rotation of the clamp rotor **30** in the following manner.

The driving of the stepping motor **4** is stopped when the wafer **6** is sufficiently moved up and subsequently the stepping motor **3** (see FIG. **2**) is driven to rotate the clamp rotor **30**. Specifically, as shown in FIG. **9**, the rotation of the stepping motor **3** is transmitted from the driving gear **61** attached to the motor shaft **3***a* to the rotor gear **36** of the clamp rotor **30** through the access gear **62** and the drive gear **63**. Thus, the clamp rotor **30** is rotated as a single rotor made of the rotor pieces **31, 32** as shown in FIG. **9**.

The stepping motor **3** is operated until the clamp rotor **30** is rotated 180° such that the rotor pieces **31, 32** change positions in relation to the fixed clamp **11** and the movable clamp **12**. Therefore, positions of the two cut tubes **7***a*, **8***a* clamped vertically one on top of the other are inverted, similarly to the case as shown in FIG. **19**.

At this time, the clamp rotor **30**, being rotationally supported by means of rollers **20** . . . , **55** . . . arranged at circumferentially equally spaced intervals, can rotate accurately about a virtual rotational axis.

Also, the cut tubes **7***a*, **8***a* have been clamped such that their cut end faces in contact with the wafer **6** are positioned one over the other with respect to the rotational axis of the rotor **30**. By the 180° rotation of the rotor **30**, changing positions of the rotor pieces **31** and **32**, accordingly, the cut end faces of the tubes **7***a*, **8***a* can be rotated about the rotational axis to be accurately placed respectively in the positions of the tubes **8***a*, **7***a* before inverting.

The tube guide **40** during inversion of the tubes **7***a*, **8***a* will be explained below. FIGS. **17**A and **17**B are side views of the tube guide **40** in the present embodiment, showing the state where the tube guide **40** clamps the tubes **7** and **8**.

Before rotation of the clamp rotor **30**, the cut tubes **7***a*, **8***a* are held vertically one on top of the other and are pinched between the guide claws **42, 42** from both sides as shown in FIG. **17**A. The cut tubes **7***a*, **8***a* are then rotated in accordance with the clamp rotor **30**. By a 90° rotation of the clamp rotor **30**, the tubes **7***a*, **8***a* will be disposed alongside each other as shown in FIG. **17**B. Subsequently, when the rotor **30** is further rotated 90°, the tubes **7***a*, **8***a* are inverted from the positions before its 180° rotation to the positions (**8***a*, **7***a*) as indicated in parentheses in FIG. **17**A. In association with rotation of the tubes **7***a*, **8***a*, the lateral dimension of the two tubes **7***a*, **8***a* become larger as shown in FIG. **17**B. At this time, the springs **43, 43** (see FIG. **7**) of the tube guide **40** will be compressed in lateral directions by the tubes **7***a*, **8***a*, thereby moving the guide claws **42, 42** outwards, i.e., away from each other, to widen the distance between the claws **42, 42**.

Accordingly, the tube guide **40** can function to reliably hold the tubes **7***a*, **8***a* regardless of how the tubes are therein arranged in parallel with each other (side-by-side or one on top of the other) by adjusting the guide claws **42, 42** into contact with the tubes in correspondence with the rotation of the tubes, specifically, by moving the guide claws **42, 42** outwards (away from each other) as the tubes are rotated, thereby enabling a smooth inverting operation.

The cut ends of the tubes **7***a*, **8***a*, which have been inverted, are disposed to face the cut ends of the tubes **8***b*, **7***b* clamped in the second tube holder **2** (see FIG. **19**) through the wafer **6** like the state immediately after cutting. Thereafter, when the wafer **6** is moved down and both cut ends of the different tubes are brought into contact with each other in the axial direction, the cut end faces of the cut tubes **7***a*, **8***a* are welded to those of the cut tubes **8***b*, **7***b* respectively to form two tubes **9, 10** (FIG. **20**).

Specifically, the stepping motor **3** that has inverted the clamp rotor **30** is first stopped and subsequently the stepping motor **4** is actuated again. Thus, the driving cam **92** (see FIG. **10**) is rotated to change the height of the peak portion of the cutting cam **94** into low, on which the roller bearing **155** (see FIG. **15**) is put, and the wafer holder **140** is moved down in association therewith. In this manner, the wafer **6** is simultaneously moved down to be withdrawn from between the tubes **7***a*, **8***a* and the tubes **8***b*, **7***b*. At this time, the wafer **6** is hooked by the stop portions **143***a*, **143***b*, so that the wafer **6** is prevented from coming off the wafer holder **140**.

The driving cam **92** for allowing the wafer holder **140** move down is integrally constructed of the cutting cam **94** and the slide cam **93** for moving the first tube holder **1**. Accordingly, simultaneously with the moving-down (oscillating-down) of the wafer holder **140** to withdraw the wafer **6** from between the cut tubes **7***a*, **8***a* and the cut tubes **8***b*, **7***b*, the sliding of the first tube holder **1** toward the second tube holder **2** side is uniquely performed. Thus, the cut end faces of the tubes **7***a* and **8***a* are pressed against the cut end faces of the different tubes **8***b* and **7***b* in the axial direction at a predetermined timing.

The first tube holder **1** is always urged by the spring **131** (see FIG. **1**) with the roller bearing **25** of the pressing arm **24** (see FIG. **6**) brought into contact with the slide cam **93** of the driving cam **92** (see FIG. **10**). Thus, while the wafer holder **140** is moved up by rotation of the driving cam **92**, the roller bearing **25** is made to roll on the flat surface portion of the slide cam **93**, and the distance between the first tube holder **1** and the second tube holder **2** is maintained constant. During the withdrawal of the wafer **6** from the tubes **7** and **8** and the slide cam **93** being rotated, the roller bearing **25** comes into contact with the sloped slide cam surface **93***a* of the slide cam **93**, rolling thereon, **8**.

The first tube holder **1** is thus pushed toward the second tube holder **2** by the urging force of the spring **131** with the slide tube **22** being slid on the guide rod **91** and the guide roller **23** being rotated in the guide block **29** for movement of the holder **1** with respect to the holder **2** in parallel relation.

Thus, the first tube holder **1** is moved closer to the second tube holder **2** side by the distance corresponding to a difference in height between the flat surface of the slide cam **93** and the slide cam surface **93***a*, though it is a very short distance. This is for pressing to connect the cut end faces of the tubes by moving the cut tubes **7***a*, **8***a* for a cutting width (approximately thickness of the wafer **6**).

The cut end faces of the tubes **7**, **8** will be welded by pressing the cut end faces to those of the different tubes, thus forming two tubes **9**, **10** which have been mutually translocated as shown in FIG. **20**.

It should be noted that the pin **129** of the buckle **125** has been inserted into the inserting groove **122** of the buckle **120**, and the buckle **125** of the first tube holder **1** is attached to the buckle **120** of the second tube holder **2** with play. The buckle **125** of the tube holder **1** is thus movable along the groove **122** with respect to the buckle **120** of the second tube holder **2**. Thus, the connection between the buckle **125** of the first tube holder **1** and the buckle **120** of the second tube holder **2** will not interfere with the slight movement of the first tube holder **1** towards the second tube holder **2** in a parallel arrangement.

Completion of the moving-down of the wafer holder **140** is detected by a limit switch **205** (see FIG. **10**) attached to the fixed clamp **81**. Upon this detection, the plunger **203** of the solenoid **202** is moved down, thereby enabling detachment of the buckles **120**, **125** from the fixed clamps **11**, **81**.

Then, the user may detach the buckles **120**, **125** and open the movable clamps **12**, **82** for taking out the tubes **9**, **10**. In the above described manner, the tube connecting operation is completed.

After that, the first tube holder **1** moved to the second tube holder **2** side stays in this position until the next tube connecting operation is performed.

When a power switch of the apparatus is turned on for the next tube connecting operation, the plunger **104** in the fixed clamp **81** of the second tube holder **2** (see FIG. **11**) detects the absence of tube. Based on this detection result, the stepping motor **4** is actuated so that the rotation of the driving cam **92** is adjusted to move the first tube holder **1** away from the second tube holder **2**.

It is to be noted that when the buckles **120**, **125** are detached and the movable clamps **12**, **82** are opened, the rotor pieces **31**, **32** are locked again (see FIG. **9**).

This locking is performed in the following manner. At first, when the user first detaches the buckle **125**, the pressing protruding piece **128** thereof is rotated to release the crank plate **66**, removing the restriction on the slide plate **65** through the crank plate **66**, thus enabling sliding of the slide plate **65**. The slide plate **65** is slid toward the clamp rotor **30** by the urging force of the spring **67** such that the engaging portion **65***p* is inserted into the locking groove **37***a*.

On the other hand, when the movable clamp **12** is opened as shown in FIG. **1**, the positioning protrusion **21** inserted in the movable clamp **12** is relatively detached. Accordingly, the flat spring **71** becomes free and the engaging piece **72** is pushed by the urging force of the spring **71** into the locking groove **37***b* of the clamp rotor **30**.

In the above manner, upon opening of the movable clamp **12**, the rotor pieces **31**, **32** are locked in positions at which the tubes have been inverted in the above-mentioned operation.

In the tube connecting apparatus in the present embodiment, due to the provision of the locking mechanism in the fixed and second clamps **11** and **12** mounting therein the rotor pieces **31** and **32**, respectively, the rotor pieces **31** and **32** are prevented from being displaced in the fixed clamp **11** and the movable clamp **12** in case the user should push the rotor pieces **31**, **32** during opening of the movable clamp **12** as illustrated in FIG. **1**. Consequently, when the movable clamp **12** is set on the fixed clamp **11** again as illustrated in FIG. **9**, the rotor pieces **31**, **32** can be positioned vertically symmetrically, which prevents the clamp rotor **30** from being displaced in the rotational direction before driving.

Inversion of the tubes can also be reliably performed by the rotation of the clamp rotor **30** to thereby ensure reliable connection of the cut end faces of the different tubes.

Further, since the locking mechanism provided in the movable clamp **12** is arranged such that the engaging piece **72** for locking the rotor pieces **31**, **32** is retracted from or inserted in the locking groove **37***b* by the positioning protrusion **21** which comes in or out of the movable clamp **12** in association with opening/closing of the movable clamp **12**. The rotor pieces **31**, **32** can be surely locked in case the user touches them in the open state as illustrated in FIG. **1**.

The locking mechanism provided in the movable clamp **11** is arranged such that the engaging portion **65***p* of the slide plate **65** is inserted into and retracted from the locking groove **37***a* in association with locking/releasing operations of the buckle **125**. Thus, similarly to above, the rotor pieces **31**, **32** can be reliably locked in case the user touches them in the open state as illustrated in FIG. **1**.

By cooperation of the engaging portion **65***p* and the engaging piece **72** with the locking grooves **37***a*, **37***b* of the rotor pieces **31**, **32**, the rotor pieces **31**, **32** can be uniquely positioned to be symmetrical between before and after inversion of the clamp rotor **30** as illustrated in FIG. **9**

Further, since the locking grooves **37***a*, **37***b* are configured such that the opposite inner wall surfaces of two protruding walls constituting a groove are substantially parallel. In relation therewith, the engaging portion **65***p* and the engaging piece **72** which are inserted therein are formed in a

square shape having peripheral faces corresponding to the inner wall surfaces.

According to the tube connecting apparatus of the present embodiment, when the movable clamps **12, 82** are set on the fixed clamps **11, 81**, the positioning protrusions **21, 89** prevent displacement of the movable clamps **12, 82** in a lateral direction (which is perpendicular to a lengthwise direction of the movable clamps **12, 82**) with respect to the fixed clamps **11, 81**, realizing alignment therebetween.

In this manner, the rotor pieces **31, 32** prevented from being displaced can constitute an accurate clamp rotor **30** when the movable clamps are set on the fixed clamps. This can avoid connection failure of the tubes. The tubes **7, 8** are reliably clamped with their interiors closed by the closing portions **33***b*, **33***b* of the clamp rotor **30** in the first tube holder **1** (see FIG. **3**) and by the holding groove **98** of the fixed clamp body **83** (see FIG. **10**) and the closing portion **114** of the movable clamp body **110** (see FIG. **12**) in the second tube holder **2**. This makes it possible to prevent leakage of liquid from the tubes when cut.

According to the tube connecting apparatus of the present embodiment, the user can accurately dispose the tubes **7, 8** by using the tube guides **40, 100**. More particularly, the distance between the guide claws **42, 42** of the tube guide **40** (see FIG. **7**) and that of the guide claws **101, 101** of the tube guide **100** (see FIG. **11**) can be adjusted to suit the outer diameters of the tubes **7, 8**. The tubes **7, 8** may be accurately set such that their central axes are in parallel disposed one on top of the other.

The guide claws **101, 101** are formed with the protrusions **101***a*, **101***a* at inner sides of the tip end portions, preventing coming off of the tubes.

According to the tube connecting apparatus of the present embodiment, due to the provision of the plunger **104** in the fixed clamp **81** of the second tube holder **2** for detecting that the tubes **7, 8** have been held, it is possible to stop tube connecting operations in a condition where the tubes **7, 8** are not held, thereby avoiding connection errors likely to be caused by clamping errors of the tubes.

At this time, since the bottom surface of the holding groove **103** from which the plunger **104** is protruded is formed flat, the area of contact surfaces of the tubes **7, 8** with respect to this bottom surface is small. The elastic force of the tubes **7, 8** is therefore strongly exerted on the contact surfaces. Thus, the plunger **104** protruding to the contact surfaces may be reliably pressed down by the elastic force of the tubes **7, 8**.

Furthermore, the tubes **7, 8** clamped by the clamp rotor **30** are symmetrically squeezed with respect to an intermediate point of respective central axes, while the tubes **7, 8** clamped by the holding groove **98** and the closing portion **114** are squeezed as to be pressed to the bottom surface of the holding groove **98** side. Accordingly, the elastic force of the tubes **7, 8** may strongly act on the bottom surface of the holding groove **98** side, ensuring pressing of the plunger **104** and making it possible to improve detecting accuracy of the sensor for tubes.

According to the tube connecting apparatus of the present embodiment, the tube guide **40** in the first tube holder **1** in which the clamp rotor **30** is rotated is configured such that the guide claws **42, 42** are slidable. Therefore, the guide claws **42, 42** can reliably hold therebetween the tubes **7***a*, **8***a* regardless of how the tubes are arranged in parallel with each other, namely, side-by-side or one on top of the other. Specifically, the guide claws **42, 42** can surely support the tubes when disposed one over the other, while mutually slide outwards to thereby permit the tubes to be smoothly inverted.

According to the tube connecting apparatus of the present embodiment, the buckle **125** pivotally provided in the movable clamp **12** of the first tube holder **1** is attached with play to the buckle **120** pivotally provided in the movable clamp **82** of the second tube holder **2** (see FIG. **13**). The pressing of the cut end faces of the tubes **7***a*, **8***a* to those of the tubes **8***b*, **7***b* can be ensured even when the movable clamp **12** of the first tube holder **1** and the movable clamp **82** of the second tube holder **2** are integrally connected through the buckles **120, 125**. Thus, the movable clamps **12, 82** are no more required to be individually manipulated when moving the movable clamp **12, 82** with respect to the fixed clamps **11, 81**. The movable clamps **12, 82** can be operated as a single unit due to the buckle **120, 125**, making it possible to eliminate the need for individual manipulation of the movable clamps **12, 82**, thus improving operability thereof.

In the tube connecting apparatus of the present embodiment, when the tubes **7, 8** are held in the first tube holder **1** and the second tube holder **2**, the movement of the plunger **203** caused in correspondence of excitation and demagnetization of the solenoid **202** prevents release of the tubes **7, 8** from the first tube holder **1** and the second tube holder **2** under a predetermined condition of operation, or for a predetermined period of operation (in the above embodiment, this period indicates the period of from the locking of the buckle **102, 125** to the completion of moving-down of the wafer holder **140**) of the apparatus after holding the tubes **7, 8**. With this arrangement, the first tube holder **1** and the second tube holder **2** can be prevented from erroneously releasing the tubes **7, 8** until completion of connection thereof. The cut end faces of the tubes **7***a*, **8***a* can be reliably connected to those of the different tubes **8***b*, **7***b*.

It is to be noted that the present invention is not limited to the above form of embodiment but may be variously modified without departing from the spirit thereof.

For instance, in the above embodiment, the locking grooves **37***a* and **37***b*, **37***a* and **37***b* are provided in the rotor pieces **31, 32**, into which the engaging portion **65***p* and the engaging piece **72** are fitted for positioning the rotor pieces **31, 32** to lock them. The locking of the rotor pieces **31, 31** may be performed by alternatives to the engaging portion **65***p* and the engaging piece **72**, which are merely inserted into rotor gears **36, 36** of the rotor pieces **31, 32**.

Further, in the above embodiment, the locking mechanism in the fixing clamp **11** side is exemplarily configured in a sliding type whereas the locking mechanism in the movable clamp **12** side is configured using a flat spring. These may be exchanged or replaced by another types.

Furthermore, for instance, the positioning protrusions **21, 89** for accurately setting the movable clamps **12, 82** on the fixed clamps **11, 81** may be provided in the movable clamps **12, 82** side.

What is claimed is:

1. A tube connecting apparatus including:

a first tube holder provided with a pair of holding members for holding a plurality of flexible tubes;

a second tube holder provided with a pair of holding members for holding the plurality of flexible tubes;

cutting and connecting means for heating and melting the plurality of flexible tubes held in the first tube holder and the second tube holder to cut the tubes by a heated cutting plate which is moved between the first tube holder and the second tube holder and to connect the tubes cut by the cuffing plate by contacting cut end faces of the cut tubes held in the first tube holder with those of the cut tubes held in the second tube holder, the

cut tubes to be connected being parts of originally different tubes;

a joining member for integrally connecting one of the pair of holding members of the first tube holder to one of the pair of holding members of the second tubeholder; and

release preventing means for preventing, under predetermined conditions, release of the tubes from the first tube holder and the second tube holder after the plurality of flexible tubes are held in the first tube holder and the second tube holder;

wherein the release preventing means prevents rotation of the joining member to prevent the release of the tubes from the first tube holder and the second tube holder.

2. The tube connecting apparatus according to claim 1, wherein the predetermined conditions include a period required until completion of connection of the tubes.

3. The tube connecting apparatus according to claim 1, wherein the release preventing means includes a solenoid and an engaging member, and release of the tubes held from the first tube holder and the second tube holder is prevented by the engaging member that moves in accordance with excitation and demagnetization of the solenoid.

4. The tube connecting apparatus according to claim 1, wherein the joining member is a buckle.

* * * * *

US005905566A

United States Patent [19]

Comulada et al.

[11] Patent Number: 5,905,566

[45] Date of Patent: May 18, 1999

[54] **LASER ABLATION TOP SURFACE REFERENCE CHUCK**

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[51] **Int. Cl.**[6] **H02N 13/00**

[52] **U.S. Cl.** **355/73**; 355/53; 430/5

[58] **Field of Search** 355/53, 73; 269/21; 430/5; 250/440.11, 442.11, 492.2, 491.1

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,412,133	10/1983	Eckes et al. .	
4,724,222	2/1988	Feldman .	
4,742,376	5/1988	Phillips	355/77
5,142,154	8/1992	Komagata .	
5,152,707	10/1992	Dougherty et al. .	
5,227,606	7/1993	Weeks et al. .	
5,374,829	12/1994	Sakamoto et al. .	
5,471,279	11/1995	Takizawa .	

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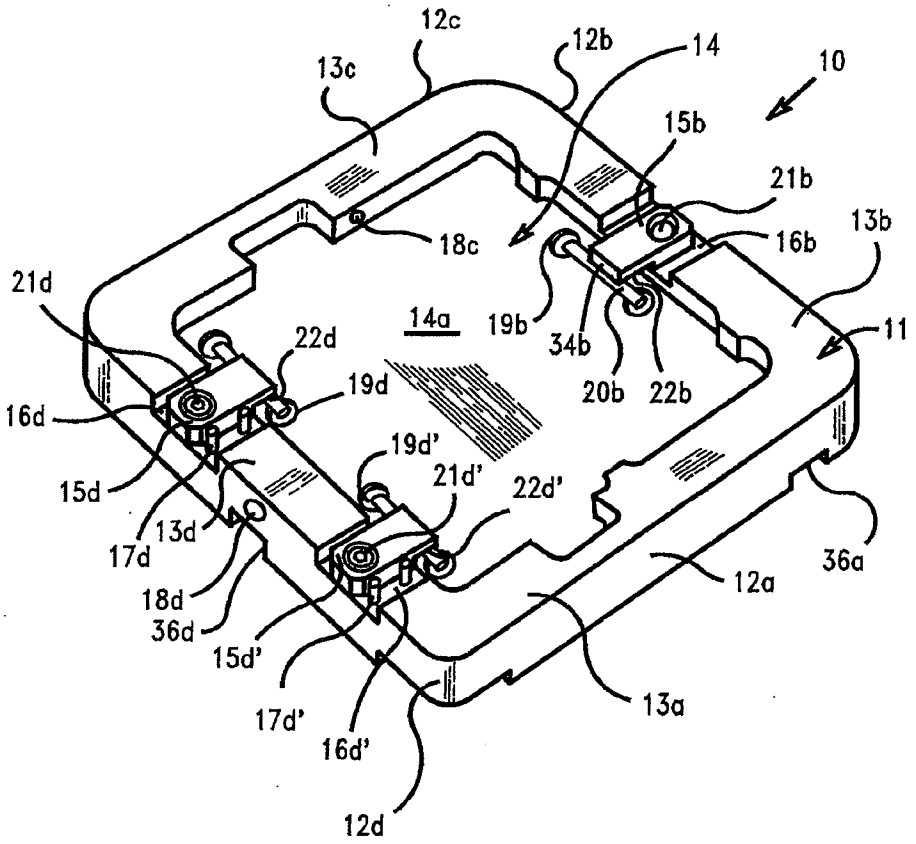
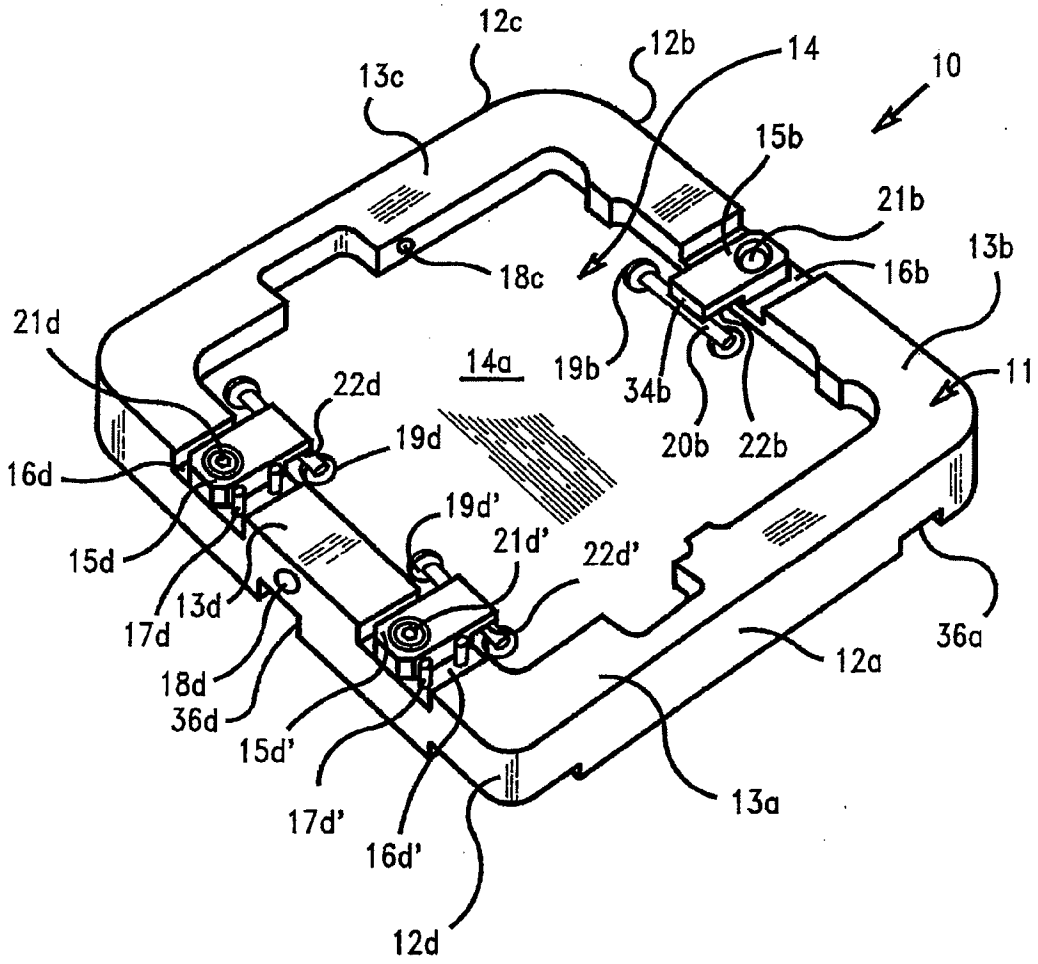
[57] **ABSTRACT**

A reference chuck which is used with a leveling device for holding microelectronic substrates and other electronic component substrates for laser ablation and other exposure processes, the chuck comprising a frame body for supporting the substrate to be processed, clamping means at the periphery of the frame body for holding the substrate to the frame body and elastomeric means for urging the substrate mounted in the reference chuck against the clamping means. The undersides of the clamping means which contacts the upper surface of the substrate forms in its tightened position a clamping plane which clamping plane is parallel with an established plane of the lower surface of the chuck. The reference chuck provides a very low profile envelope for use with conventional leveling devices and the top surface of the substrate and the lower surface of the reference chuck are in parallel planes when the chuck is placed on the working surface of the leveling device.

10 Claims, 4 Drawing Sheets

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36a
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13a
17d'
16d'
12d

FIG. 1

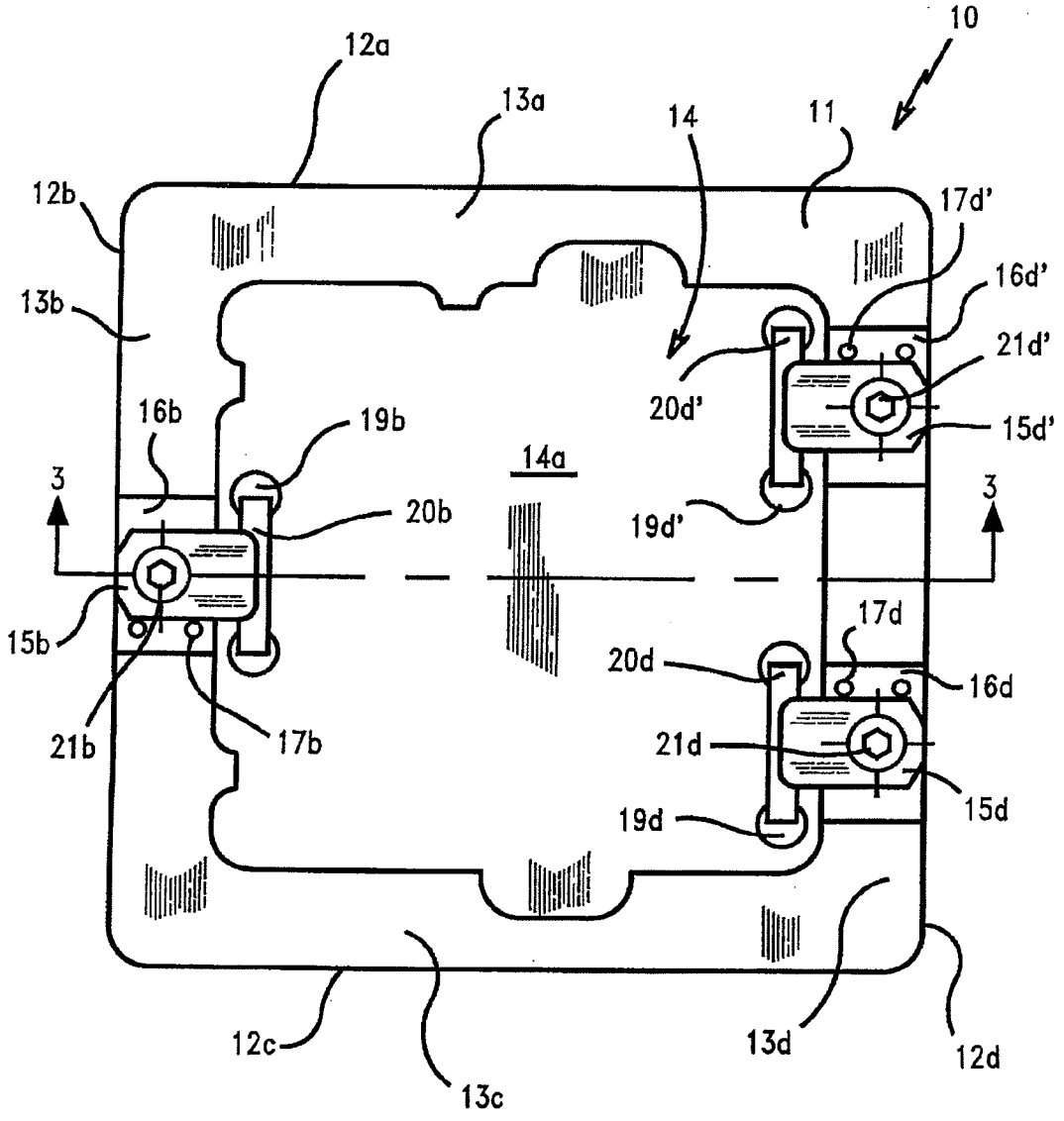

10
12a
13a
14
11
12b
17d'
16d'
13b
21d'
20d'
15d'
16b
19b
14a
3
3
20b
19d'
17d
15b
20d
16d
21b
17b
21d
15d
19d
12c
13c
13d
12d

FIG. 2

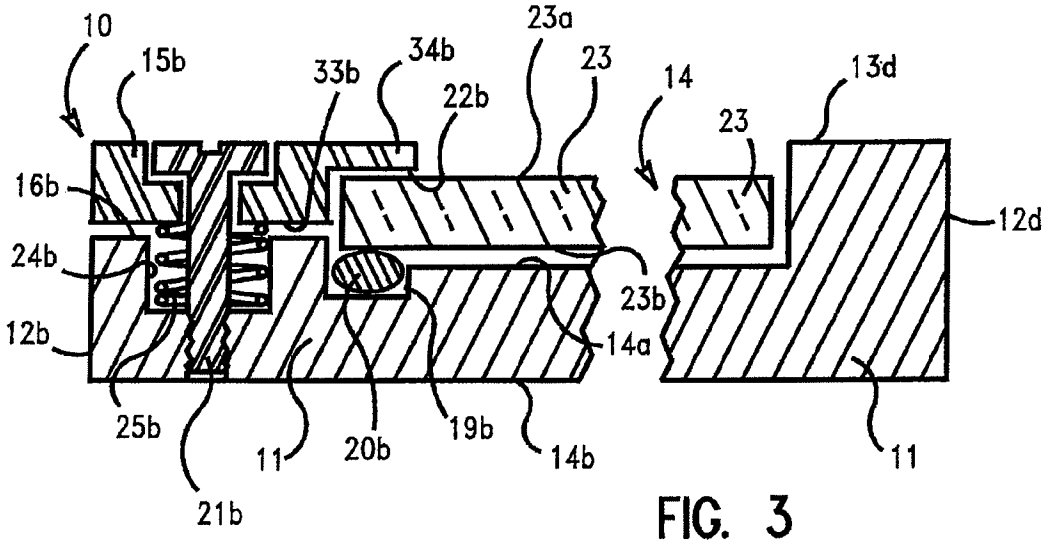

10
15b
33b
34b
23a
22b
23
14
13d
23
16b
12d
24b
23b
12b
14a
25b
11
20b
19b
14b
11
21b

FIG. 3

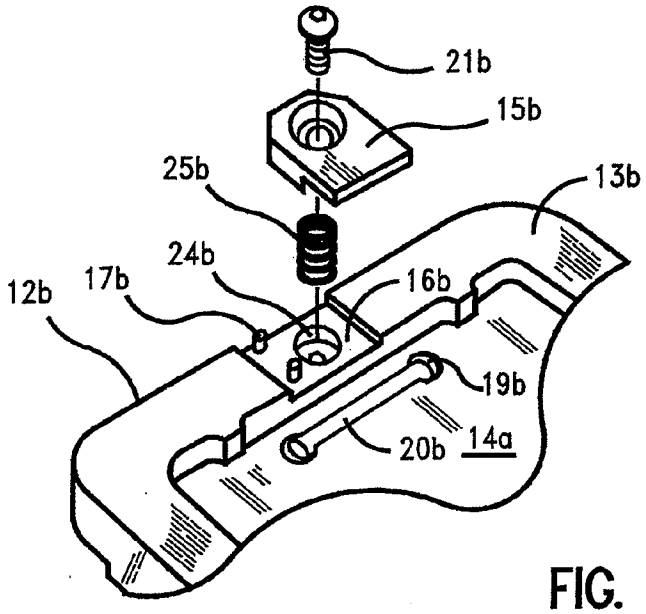

21b
15b
25b
13b
24b
12b
17b
16b
19b
20b
14a

FIG. 4

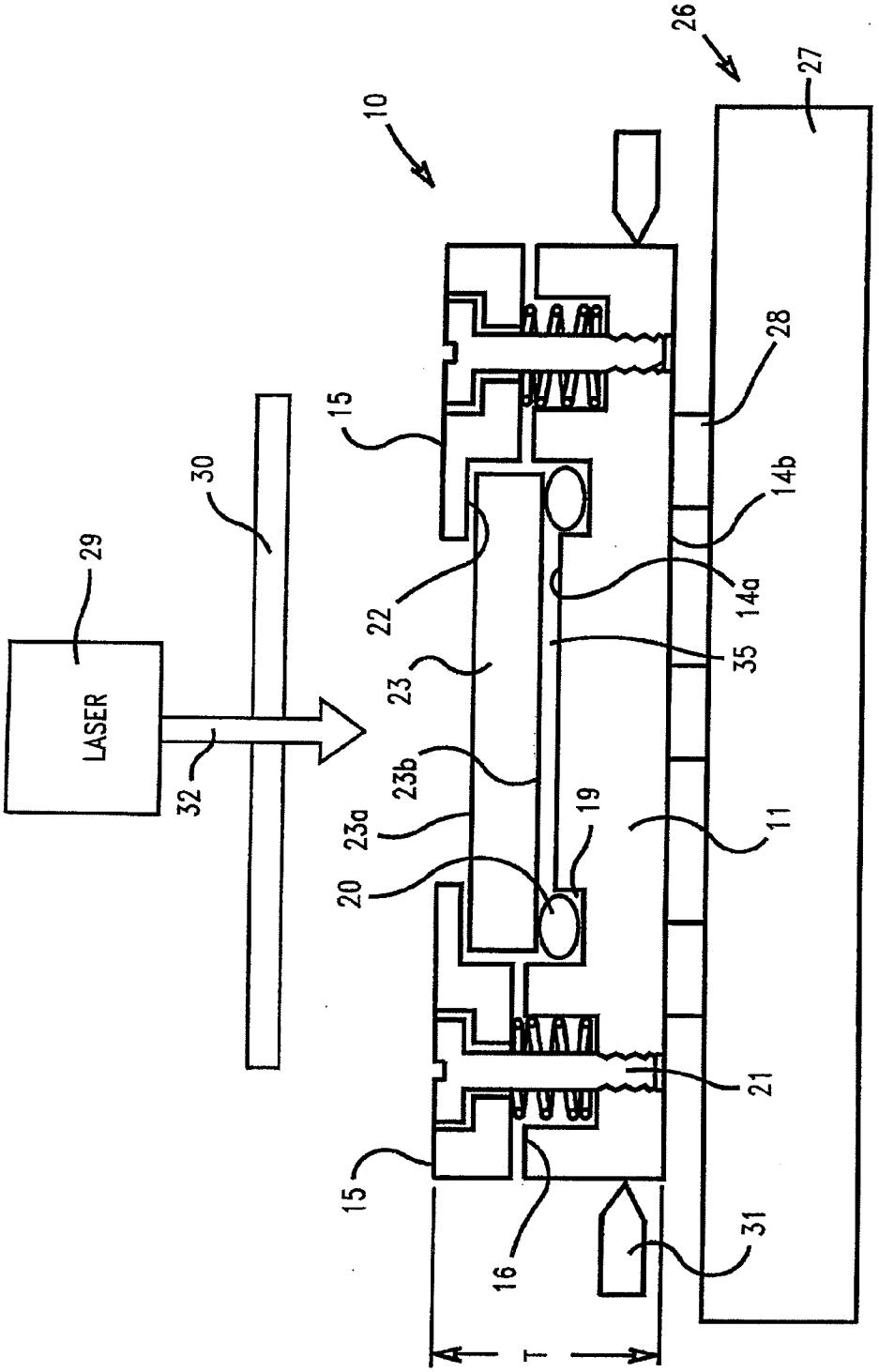

26
27
10
28
15
30
14b
29
22
14a
35
LASER
23
23b
32
19
11
23a
20
21
15
16
31
A
T

FIG. 5

LASER ABLATION TOP SURFACE REFERENCE CHUCK

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a chuck for holding microelectronic substrates and other electronic component substrates during the substrate manufacturing process, and, in particular, to a reference chuck for use with leveling devices, e.g., optical types, to enhance the effectiveness of the leveling device in the lithography or ablation steps of the manufacturing process.

2. Problem to be Solved

The manufacture of microelectronic substrates or other electronic component substrates require a number of steps to fabricate the desired circuit on the substrate. In the lithography steps of the manufacturing process lithography or ablation tools are used to ablate vias in the top surface metallurgy (TSM) e.g., polyimide coating, of in-process microelectronic substrate packages. Most lithography or ablation tools have a very limited travel with which to level a microelectronic substrate or other electronic component. This limited travel is normally due to the need to have a very rigid focus/leveling system. The terms microelectronic substrates and substrates will be used interchangeably herein and it should be kept in mind that the term "substrate" may apply to many types of microelectronic and electronic substrates.

As the metal loading in substrate packages increases and becomes more non-symmetric, it has become very difficult to make substrates where the top side metallurgy(TSM) and bottom side metallurgy (BSM) surfaces are parallel. This non-parallelism in combination with the limited travel of leveling systems is the main cause of leveling problems since the systems are not able to travel far enough to level BSM referenced substrates. When a substrate is processed in a laser ablation or other lithography tool, it generally has to be brought into the focus range and leveled or distortions in the exposed substrate result with the circuit being either nonfunctional or, at best, having less than optimum performance.

In general, leveling devices comprise a workstation consisting of parallel base plates which carry a substrate X-Y stage, a mask X-Y stage and supports a bridge assembly. The projection optics consist of a 1:1 telecentric lens. The tool is typically enclosed in an environmental chamber to maintain a Class 10 environment.

An ablation leveling system typically processes a single substrate at a time and the substrate is loaded onto the substrate chuck located on top of the substrate X-Y table. The X-Y table then positions the substrate under an optical auto focus assembly. Next, a Z axis slide and two leveling drives located in the substrate stage are used to focus and level the substrate. The tool also automatically loads a mask using an AHSM (Automatic Handling System Mask) onto the mask chuck located on top of the mask X-Y table. A pattern recognition system then locates the pre-align targets which are located at each corner of the substrate or mask. The targets are mapped and the locations recorded. The tool calculates a global X-Y translation and global rotation, which are used as a basis for finding the center of the substrate or mask. After substrate and mask prealignment, the mask is aligned to the substrate using the on axis alignment system. When the substrate and mask are aligned, data from a stored program are used to ablate the part. Multiple masks may be used. After ablation the part is unloaded.

Both the substrate and mask systems have a stage that positions the mask or substrate relative to the X-Y table and a chuck that holds the substrate or mask.

An auto focus and leveling system is designed to measure the distance between the auto focus sensor and the top surface of the substrate. This distance is controlled by drive actuators in the substrate stage. The Z-axis drive moves the substrate up and down to focus differing substrate thicknesses. The top leveling drives are used to compensate for any wedge in the substrate.

Automatic focus and automatic leveling are generally achieved by projecting a line of light on the substrate top surface and reading the reflected light with a dual photo detector. The light is typically emitted from a fiber optic light guide connected to a Hg arc lamp light source and filtered for 365 nm.

A common problem in the leveling step of the substrate manufacturing process is the large percentage of leveling errors due to distortion of the substrate. The substrate must be essentially flat or planar to achieve a high resolution pattern in the lithography process. This distortion is typically more than the amount of adjustment that the leveling cams of the leveling tool can perform. The cams are used to automatically raise or lower the substrate into the focus and level position. Some substrates pass the focus/level after several re-trys while others have to be completely removed from the tool, repositioned in the holding fixture, and then tried again. Each re-try where the substrate has to be removed and repositions takes time and this is of great impact to the through-put and delivery schedule of the substrate products.

One substrate fixturing method is to place the substrate onto a chuck which uses the bottom surface of the substrate at three points to establish a reference plane and then to bank the substrate into a fixed chuck corner relative to a set corner of the product. Some substrate products however are not very parallel between the top and bottom surfaces due to the density of the circuitry and, therefore, distortion of the exposed substrate at the focus/level alignment of the tool and/or multiple leveling procedures results.

Bearing in mind the problems and deficiencies of the prior art, it is therefore an object of the present invention to provide a reference chuck used with leveling devices to hold substrates in lithographic or ablation processes to increase the effectiveness of both the leveling process and the lithography or ablation process.

It is another object of the present invention to provide a method for making electronic components, e.g., microelectronic substrates, which are made by lithographic or ablation methods and in particular lithographic or ablation processes which use leveling devices.

A further object of the invention is to provide electronic components, e.g., microelectronic substrates, made using the method and apparatus of the invention.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

SUMMARY OF THE INVENTION

The above and other objects and advantages, which will be apparent to one of skill in the art, are achieved in the present invention which is directed to, in a first aspect, a top surface reference chuck for holding microelectronic substrates or other electronic component substrates during laser ablation or other lithography exposure or ablation steps of

the substrate manufacturing process which lithography or ablation steps use leveling devices to provide a level substrate surface for exposure or ablation, wherein the chuck establishes a substrate top surface and lower chuck surface having parallel planes by utilizing clamps which secure the substrate to the chuck and which clamp/substrate mating surfaces form a clamping plane with the clamping plane and lower chuck surface plane being in parallel planes and which lower chuck surface rests upon the leveling device and which lower chuck surface is planar and preferably in a three point comprised planar surface.

The top surface reference chuck comprises a plurality of resilient seats, e.g., three elastomeric seats situated preferably diametrically opposed at two sides of a rectangular chuck and are at the periphery of a central recess opening of the chuck upon which seats the lower surface of the substrate rests. The substrate is secured in the chuck with clamps, preferably three clamps and preferably positioned adjacent and proximate to the elastomeric seats, which clamps are positioned on the upper surface of the chuck and when the clamps are tightened, the substrate is squeezed against the resilient seats and the substrate urged against the underside clamping surface of the clamps. The underside clamping surfaces of the clamps when tightened form a parallel plane with the lower plane surface of the chuck. The parallel plane top surface of the substrate is established by the resilient seats urging the substrate against the underside clamping surface of the clamp.

The chuck has been found to eliminate many of the substrate leveling concerns at the laser ablation or other lithography step of the manufacturing process.

In a further aspect of the invention, a top surface reference chuck for holding a microelectronic substrate or other electronic component substrate to be exposed or ablated in a lithography process such as a laser ablation process comprises:

a frame body for supporting the substrate to be exposed, e.g., laser ablated, the frame body having a lower surface which is planar, preferably three point comprised planar, and which is positioned on a leveling device;

a plurality of movable clamping means secured at the periphery of the frame body for securing the substrate to the frame body, the underside clamping surfaces of the clamping means contacting the upper surface of the substrate and forming a clamping plane, with the plane of the lower surface of the frame body and clamping plane being parallel planes when the clamping means are tightened and providing a top surface of the substrate which is level in its secured position when the leveling device is level; and

resilient means provided in the frame body, preferably at the periphery of the frame body and adjacent the clamps, for urging the secured and supported substrate against the clamping surface of the clamping means.

In preferred aspect of the invention, the frame body further comprises registration means on at least two sides of the frame body (at 90° for a rectangular frame body) for positioning the supported substrate on the frame body. The clamping means are movable upward and downward and sideways to allow top mounting on the substrate on the frame body. The clamping means preferably comprise a spring or other such resilient means to assist in moving the clamping means when the clamping means are loosened to mount or remove the substrate from the chuck. The frame body preferably has a central recess area in which the substrate is positioned. The frame body is typically rectangular and usually square such as a semiconductor chip with the recess being generally of the same configuration and a slightly larger size than the substrate to be mounted.

It is an important aspect of the invention that the frame body have a low profile thickness so as to be compatible with conventional leveling devices. To support the substrate or other electronic component substrates which are relatively heavy, it is important that the resilient means, preferably an elastomeric material, have the necessary resiliency to urge the substrate securely against the clamping surface of the clamp. It is preferred to employ elastomeric materials such as 60–70 Durometer Viton, nitrile or Neoprene in the recess area of the frame body for urging the supported substrate against the clamping means. The use of an elastomeric material allows the frame body to have a low profile thickness and to be compatible with conventional leveling devices. An elastomeric material is preferable because it has resiliency and is non-abrasive and makes minimal contact with the substrate.

It is another important aspect of the invention that the undersides of the clamps, which undersides mate with the top surface of the substrate being mounted (clamping surface), form in their tightened position a plane which is parallel with the plane of the lower surface of the reference chuck. In another preferred embodiment, the underside of the clamp which mates with the upper surface of the frame body are both on parallel planes so that the (1) lower surface of the chuck, (2) the upper surface of chuck, (3) the surface of the clamp which mates with the upper surface of the chuck and (4) the clamping surface are all in parallel planes. The plane of each surface may be defined by three connecting points on the surface. Thus, if the chuck has three clamps, a point on the underside of each clamp (clamping surface) when connected will be in a parallel plane with the plane of the lower chuck surface. The elastic memory of the compressed elastomer seats provide the necessary compressive force needed to urge the substrate upward and against the underside of the clamp.

In a further aspect of the invention, a method is provided for making electronic substrates by selectively exposing a circuit pattern on the surface of the electronic component substrate the method comprising the steps of:

mounting the substrate in a reference chuck comprising:

a frame body for supporting the substrate to be exposed, e.g., laser ablated, the frame body having a lower surface which is planar and preferably three point comprised planar and which is positioned on a leveling device;

a plurality of movable clamping means secured at the periphery of the frame body for securing the substrate to the frame body, the underside clamping surfaces of the clamping means contacting the upper surface of the substrate and forming a clamping plane with the plane of the lower surface of the frame body and the clamping plane formed by the underside surfaces of the clamping means being parallel planes when the clamping means are tightened, and providing a top surface of the substrate which is level in its secured position when the leveling device is level; and

resilient means provided in the frame body, preferably at the periphery of the frame body and adjacent the clamps, for urging the secured and supported substrate against the clamping surface of the clamping means; positioning the chuck on a leveling device;

moving the chuck to the desired position for exposure or ablation; and repeating the above steps until the exposure or ablation is completed and the substrate made.

In an additional aspect of the invention microelectronic substrates or other electronic components are provided which have been made using the reference chuck and method of the invention as described hereinabove.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the invention are believed to be novel and the elements characteristic of the invention are set forth with particularity in the appended claims. The figures are for illustration purposes only and are not drawn to scale. The invention itself, however, both as to organization and method of operation, may best be understood by reference to the detailed description which follows taken in conjunction with the accompanying drawings in which:

FIG. **1** is a perspective view of a reference chuck of the invention.

FIG. **2** is a top plan view of the reference chuck of the invention as shown in FIG. **1**.

FIG. **3** is a cross-sectional view of the reference chuck of FIG. **2** taken along lines **3**—**3**.

FIG. **4** is an exploded perspective view of a section of a reference chuck of the invention showing in detail the spring clamp mechanism used with the reference chuck.

FIG. **5** is a schematic of a reference chuck of the invention having a wafer mounted thereon which reference chuck is positioned on a leveling device used to laser ablate the wafer.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In describing the preferred embodiment of the present invention, reference will be made herein to FIGS. **1**–**5** of the drawings in which like numerals refer to like features of the invention.

Referring to FIG. **1**, a reference chuck generally shown as **10** comprises a frame body **11** having sides **12***a*, **12***b*, **12***c* and **12***d*. The frame body **11** is shown as substantially square and has a square central recess area **14**. The frame body may be any shape necessary to hold the desired substrate to be laser ablated or otherwise treated and is typically made of aluminum and/or stainless steel. Teflon impregnated aluminum is preferred. The frame body **11** has peripheral walls **13***a*, **13***b*, **13***c* and **13***d* defining central recess area **14**. The recess area **14** has an upper surface **14***a* and a lower surface **14***b* (not shown). The lower surface **14***b* is planar and extremely flat. Preferably, the lower surface **14***b* is three point surface contact planar and may be established by using three area recesses in the lower part of the frame body. As shown in FIG. **1**, recessed areas **36***d* and **36***a* (together with **36***b* or **36***c* not shown) are formed to be flat surfaces on which the three leveling pads of the leveling device are positioned. This establishes in effect a flat, planar lower chuck surface **14***b*.

The reference chuck **10** is shown having three clamps **15***b*, **15***d* and **15***d*' which are positioned in wall recesses with clamp **15***b* being positioned on wall recess surface **16***b*, clamp **15***d* being positioned on wall recess surface **16***d* and clamp **15***d*' being positioned on wall recess surface **16***d*'. Additional clamps may be used for certain applications. The clamps are typically made of hard coated, (e.g., TiN) hardened steel. The wall recess surfaces **16***b*, **16***d* and **16***d*' form a plane which is parallel with the plane formed by the three recessed areas **36***a*, **36***d* and **36***c* or **36***b* of lower chuck surface **14***b*. Thus, when the chuck is resting on the leveling device pads (usually three), the lower surface **14***b* of the chuck is in a parallel plane with the plane formed by the wall recess surfaces **16***b*, **16***d* and **16***d*'.

Clamp registration pins **17***d* and **17***d*' are shown abutting the edge of clamps **15***d* and **15***d*' respectively. The pins are employed to prevent the tightened clamps from turning and to hold the clamps in the desired clamping position versus the substrate mounted in recess area **14** on recess surface **14***a*.

Registration pins or set screws **18***c* and **18***d* are used to align and secure the substrate in recess **14**.

Openings **19***b*, **19***d* and **19***d*' are provided in the frame body to support resilient means or elastomeric seats **20***b*, **20***d* and **20***d*' (**20***d* and **20***d*' not shown). The openings **19***b*, **19***d* and **19***d*' and elastomer seat **20***b* are shown as elongated but any suitable opening and elastomeric seat size may be employed which will effectively urge the top surface of a mounted substrate against the underside **22***b*, **22***d* and **22***d*' of clamps **15***b*, **15***d* and **15***d*' respectively. The resilient means or elastomeric seats may be any suitable material as noted above with nitrile being preferred.

The clamps **15***b*, **15***d* and **15***d*' are secured to the frame body **11** by clamp fasteners **21***b*, **21***d* and **21***d*', respectively. The clamp fasteners are typically bolts which are threaded into a threaded opening in the frame body **11** to tighten the clamp to the frame body. The clamps are shown having a protruding edge **34***b* (only **34***b* shown) overhanging the recess area **14** with the underside of the clamp edge designated as **22***b*, **22***d* and **22***d*'. The clamp undersides (termed the "clamping surface") contact the substrate when the substrate is mounted and secured in the chuck.

FIG. **2** is a top plan view of the chuck **10** shown in FIG. **1**.

FIG. **3** is an enlarged cross-sectional view of chuck **10** shown in FIG. **2** taken along lines **3**—**3** of FIG. **2**. Frame body **11** is shown having a lower surface **14***b* and upper surface **14***a* which defines recess **14**. The frame body **11** is shown terminating at recess surface **16***b* which is the surface to which clamp **15***b* is secured. Opening **19***b* in frame body **11** is shown holding elastomer seat **20***b* in a compressed form. Threaded opening **24***b* aligns with an opening in the clamp and clamp fastener **21***b* is used to secure the clamp to the frame body **11**. Clamp **15***b* has a protrusion **34***b* overhanging recess area **14**, with the protrusion having an underside **22***b*. A substrate **23** mounted on the upper surface **14***a* of recess **14** contacts the clamp overhang underside **22***b* of clamp **15***b* when the clamps are tightened. The elastomeric material urges the upper surface **23***a* of the substrate to contact the clamp overhang underside **22***b*. Side **12***d* and wall **13***d* show the opposed side of the frame body.

It is an important feature of the invention that the underside **22** of the clamps **15** in the fastened position form a parallel plane with the established three point plane of the lower side **14***b* of the chuck. Referring to FIG. **3**, underside **22***b* of clamp **15***b* in the fastened positioned with clamp **15***d* and **15***d*' form a parallel plane with the lower three point surface **14***b* of frame body **11**. The three point surface **14***b* is established by recesses **36***d*, **36***a* and **36***b* or **36***c* of FIG. **1**. When these two surfaces are in parallel planes, substrate **23** (and upper surface **23***a*) are in parallel planes with the leveling device and the leveling device may be effectively and efficiently used to position the substrate for exposure. Preferably, clamping surfaces **16***b*, **16***d* and **16***d*' and the lower clamp sides **33***b*, **33***d* and **33***d*' of clamps **15***b*, **15***d* and **15***d*', respectively, form parallel planes with the planes of lower surface **14***b* of chuck **10** and clamping surfaces **22**.

Referring to FIG. **4**, an exploded view of clamp assembly **15***b* is shown. Accordingly, clamping surface **16***b* of frame

body **11** has an opening **24***b* therein. The opening supports spring **25***b* and when clamp **15***b* is assembled to frame body **11** the clamp compresses spring **25***b* and clamp **15***b* is secured by clamp fastener **21***b*. Registration pins **17***b* maintain clamp **15***b* in the fastened position and prevent clamp **15***b* from turning and affecting the substrate position in the chuck.

FIG. **5** shows reference chuck **10** having a mounted substrate **23** and being used with a leveling system shown generally as **26** to expose the substrate. The leveling system **26** comprises a base **27** which has three leveling pads **28** on the upper surface thereof. The lower three point planar surface **14***b* of reference chuck **10** preferably as formed by recesses **36***d*, **36***a* and **36***b* or **36***c* is positioned on the leveling pads **28** and secured to the leveling system by jaws **31**. A laser beam apparatus **29** emits a laser beam **32** through mask **30** which laser beam impinges on the surface of substrate **23** exposing a pattern for making the substrate. Substrate **23** is shown being secured in reference chuck **10** by the urging action of elastomers **20** on the underside **23***b* of substrate **23** which upper surface **23***a* is held against the underside **22** of clamp **15**. The height of the reference chuck **10** including the mounted substrate **23** is shown as T. This distance is typically 12 mm or less and because of the relatively heavy weight of the substrates, the use of an elastomer seat as the resilient means was preferable due to its high resiliency to size ratio and its ability to support the substrate weight while still applying the necessary compressive force. Elastomers are also non-abrasive to the substrate. It is also highly preferred that there be a gap **35** between the upper surface **14***a* of frame body **11** and the lower surface **23***b* of substrate **23** to provide the parallel planar surfaces and enhanced operational results.

Referring to FIG. **5**, the method of the invention may be described. Accordingly, clamp fasteners **21** would be unscrewed and clamps **15** moved upwards and sideways typically 90° opening up recess area **14** in which the substrate **23** will be mounted. The mounted substrate is then banked into a corner with set screws **18** (not shown) and the clamps **15** are returned to the clamping position and tightened with fasteners **21** to move the clamps vertically downward toward and against the upper surface **23***a* of substrate **23**. The clamped substrate compresses the elastomer **20** and the compressed elastomer **20** urges the substrate upward against the undersides **22** of clamps **15**. The plane of upper surface **23***a* of the substrate **23** is now precisely parallel to the plane of lower three point surface **14***b* of chuck **10** because the plane formed by the undersides **22** of clamps **15** and the lower three point surface **14***b* of chuck **10** are in parallel planes.

The above description was primarily directed to the use of a three point reference plane to establish a planar surface and the use of a three pad leveling device to level the substrate. It will be apparent to those skilled in the art however, that the invention is directed to utilizing a chuck having a planar lower surface which is rested on the leveling device and secured thereto. The substrate mating surfaces of the clamping means (clamping surfaces) form a plane which is parallel with the plane of the lower surface of the chuck and establishes an upper substrate surface which is level when the clamps are tightened to the chuck and secure the substrate.

In the preferred embodiment, three recesses are formed in the lower portion of the frame body which are three point planar and which recesses rest on the leveling pads of the leveling tool. Recesses are formed on the upper portion of the frame body to which clamps are mated and secured. The clamping surfaces of the clamps which secure the substrate to the frame body form a clamping plane which plane is parallel to the lower planar surface of the frame body. The resulting reference chuck when used with a leveling device provides an efficient manufacturing process for making microelectronic substrates requiring leveling operations to ablate or expose the substrate.

While the present invention has been particularly described, in conjunction with a specific preferred embodiment, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. It is therefore contemplated that the appended claims will embrace any such alternatives, modifications and variations as falling within the true scope and spirit of the present invention.

Thus, having described the invention, what is claimed is:

1. A top surface reference chuck for securing a substrate with an upper surface to be exposed or ablated in a lithography or ablation process comprising:

a frame body for supporting the substrate to be exposed or ablated;

the frame body having a lower planar surface which is positioned on a leveling device;

a plurality of movable clamping means, each with an underside surface, at the periphery of the frame body for securing the substrate to the frame body wherein the underside surfaces of the clamping means mate with the upper surface of the substrate such that when the clamping means are tightened, the underside surfaces of the clamping means form a clamping plane, the clamping plane being parallel with the lower planer surface of the frame body; and

resilient means provided in the frame body, underneath the clamping means, for urging the supported substrate against the underside surface of the clamping means.

2. The reference chuck of claim **1** wherein the frame body has a central recess area to support the substrate therein.

3. The reference chuck of claim **2** wherein the frame body comprises registration means for positioning the supported substrate in the recess of the frame body.

4. The reference chuck of claim **3** wherein the frame body is rectangular.

5. The reference chuck of claim **4** wherein the frame body is square and the recess area is square.

6. The reference chuck of claim **5** wherein the registration means are on at least two sides of the frame body.

7. The reference chuck of claim **6** wherein the resilient means is an elastomeric material.

8. The reference chuck of claim **7** wherein the clamping means is rotatable to allow top mounting of the substrate in the recess of the frame body.

9. The reference chuck of claim **8** wherein the clamping means has clamping registration means to prevent turning of the clamping means when the clamping means are tightened to secure the substrate.

10. A top surface reference chuck for securing a substrate with an upper surface to be exposed or ablated in a lithography or ablation process comprising:

a frame body for supporting the substrate to be exposed or ablated;

the frame body having a periphery, and a lower planar surface which is positioned on a leveling device;

a plurality of movable clamping means, each with an underside surface, at the periphery of the frame body for securing the substrate to the frame body, wherein the underside surfaces of the clamping means mate

with the upper surface of the substrate such that when the clamping means are tightened, the underside surfaces of the clamping means form a clamping plane, the clamping plane being parallel with the lower planer surface of the frame body; and

a plurality of elastomeric material seats provided in the frame body for urging the supported substrate against the underside surface of the clamping means.

* * * * *

US005458330A

United States Patent [19]

Baum

[11] Patent Number: 5,458,330

[45] Date of Patent: * Oct. 17, 1995

[54] **COMPOSITE BASEBALL BAT WITH CAVITIED CORE**

[75] Inventor: **Charles S. Baum**, Traverse City, Mich.

[73] Assignee: **The Baum Research & Development Company**, Traverse City, Mich.

[*] Notice: The portion of the term of this patent subsequent to May 19, 2009 has been disclaimed.

[21] Appl. No.: **262,432**

[22] Filed: **Jun. 20, 1994**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 137,694, Oct. 15, 1993, which is a continuation-in-part of Ser. No. 883,263, May 14, 1992, abandoned, which is a continuation-in-part of Ser. No. 518,782, May 4, 1990, Pat. No. 5,114,144.

[51] **Int. Cl.**[6] **A63B 59/06**

[52] **U.S. Cl.** ..... **273/72 R**

[58] **Field of Search** ..... 273/72 R, 72 A, 273/735, 67 R, DIG. 23, DIG. 8, 22 R, 80.3; 428/106, 285, 35.6; 156/245; 440/101

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,114,144 5/1992 Baum ..... 273/72 R

Primary Examiner—Mark S. Graham
Attorney, Agent, or Firm—Gifford, Krass, Groh, Sprinkle, Patmore, Anderson & Citkowski

[57] **ABSTRACT**

A baseball bat or the like comprises a tube formed with an outer layer of wood-like veneer covering a layer of fiber reinforced resin, with the tube layers being impregnated with and bonded to one another with a cured resin. The ends of the tube are closed off with caps adhered to the tube and preferably molded in place. The tube preferably has a foam or aluminum core including a central cavity, said core having sufficient resiliency to allow the tube to resiliently deform during impact with a baseball. The product is formed by molding over a form which may constitute the cavitied foam core or, alternatively, a forming mandrel which is removed after the resin is cured. The cavity may be filled with a material which is less dense than the core.

12 Claims, 5 Drawing Sheets

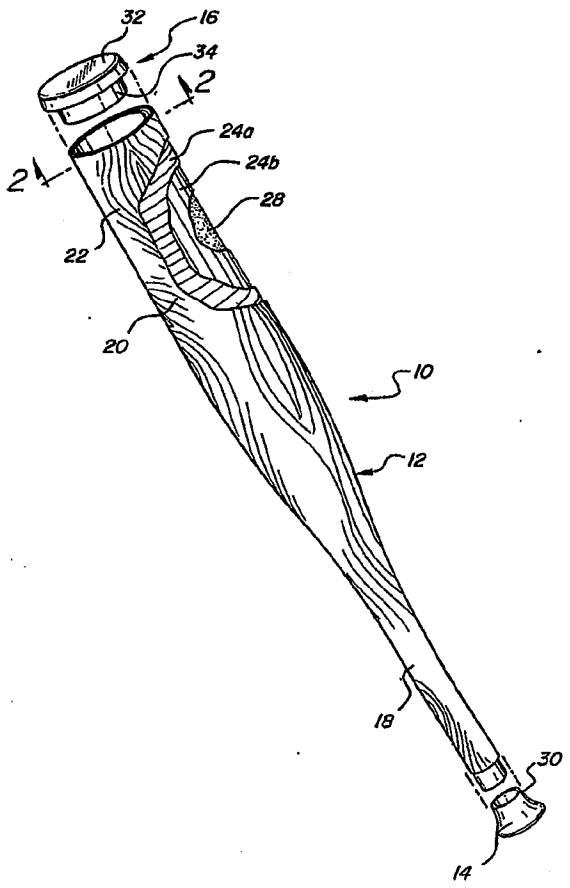


FIG-1

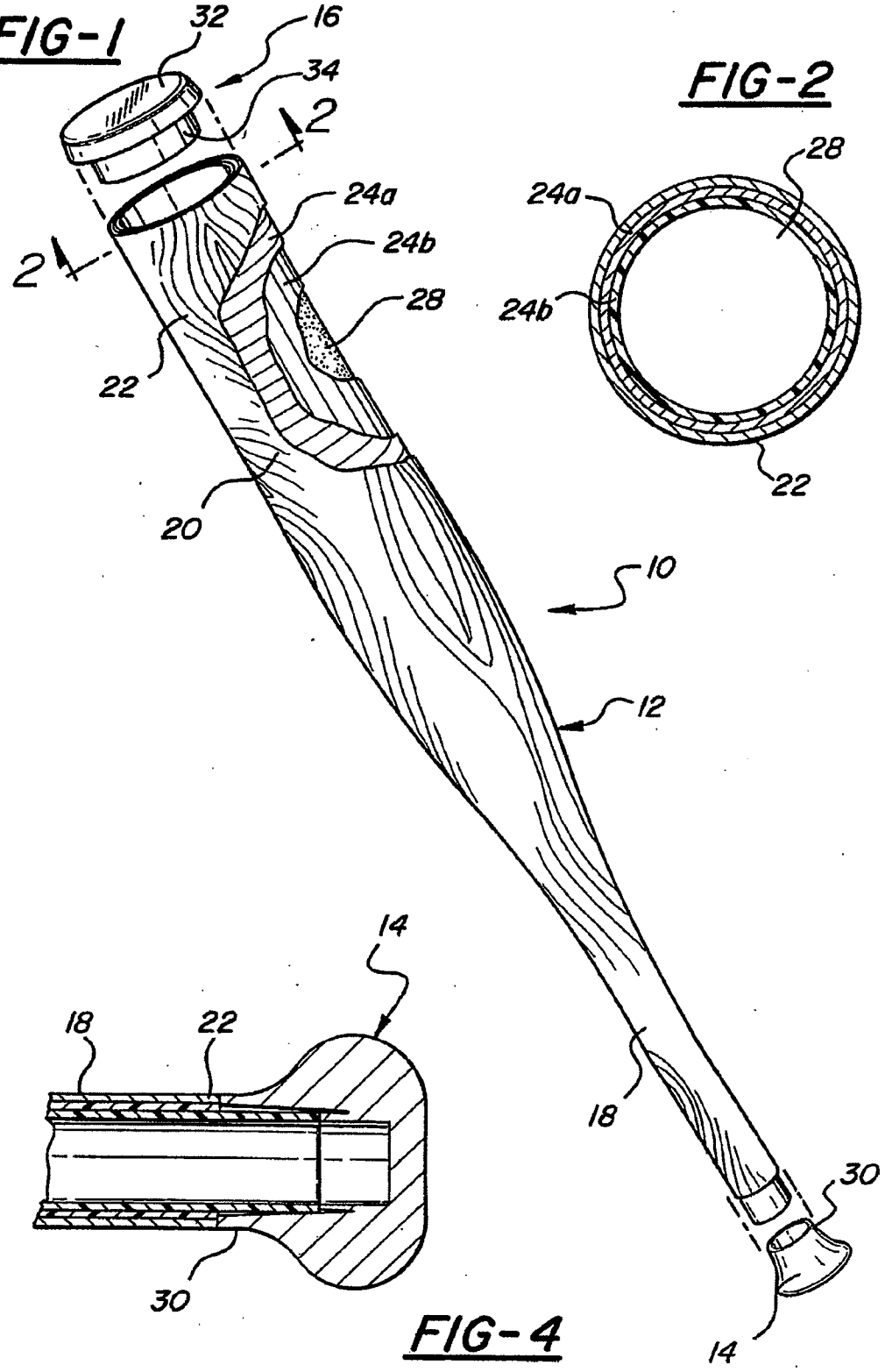


FIG-2

FIG-4

FIG-3

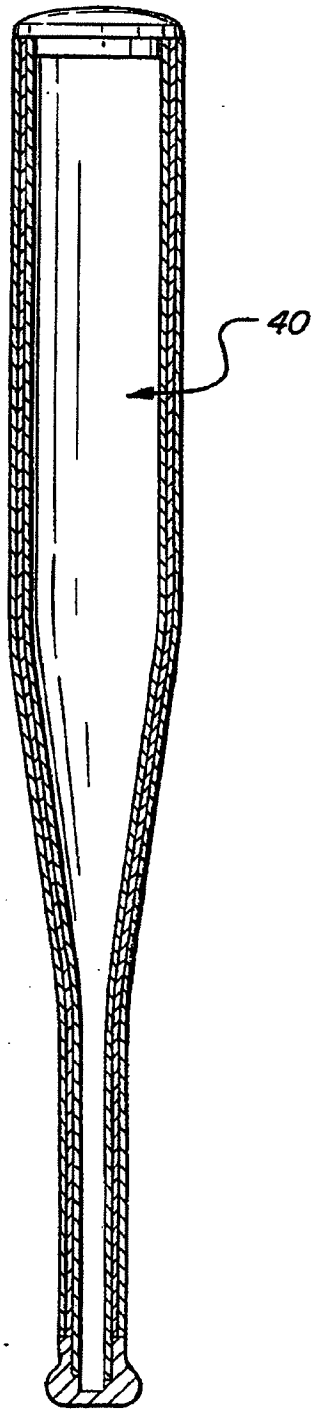
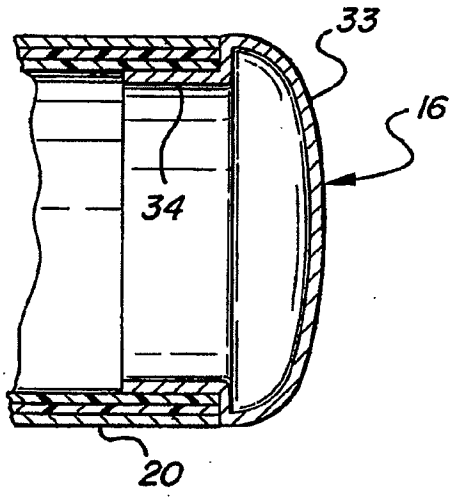


FIG-5



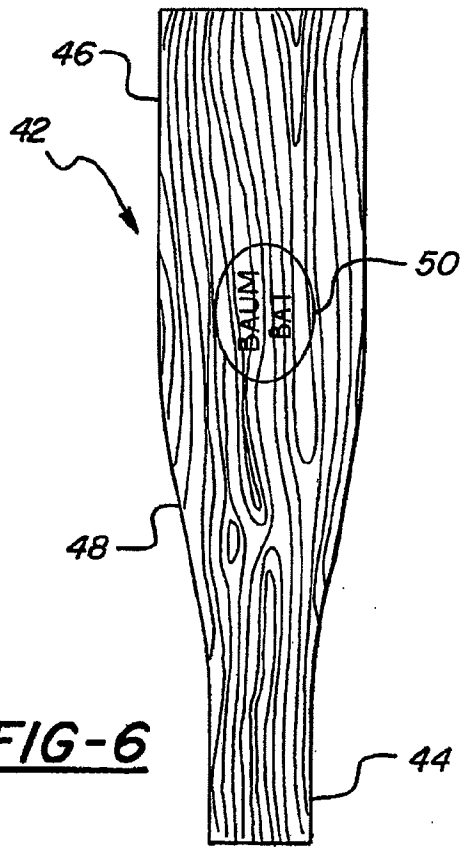
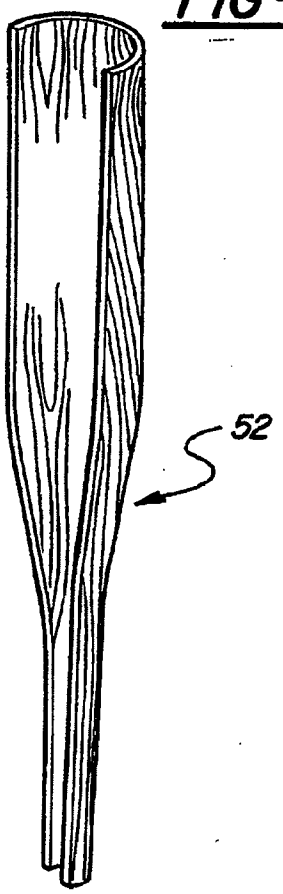


FIG-6

FIG-7



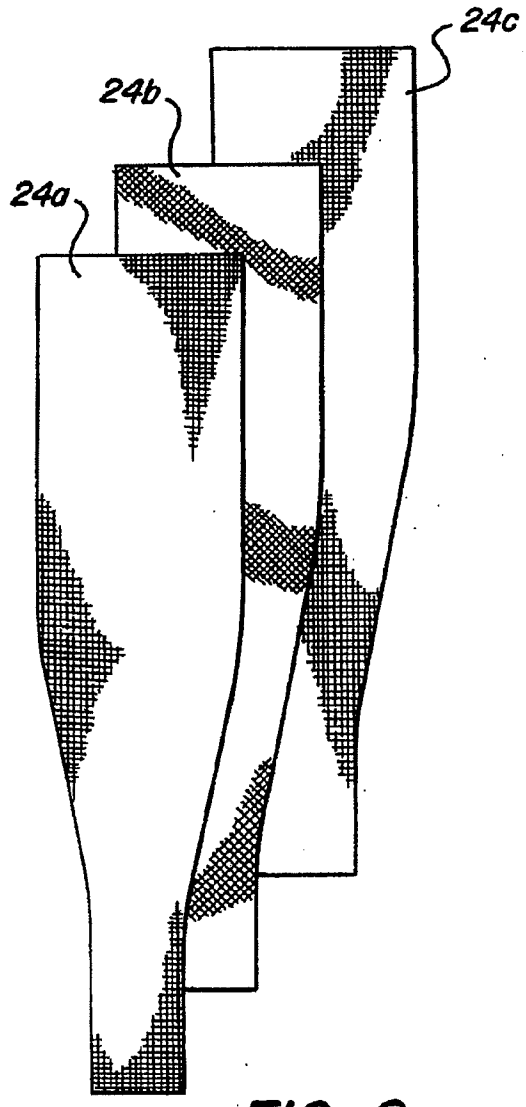


FIG-8

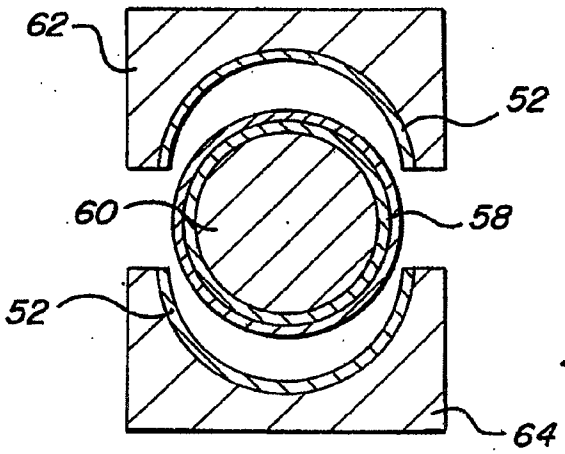


FIG-10

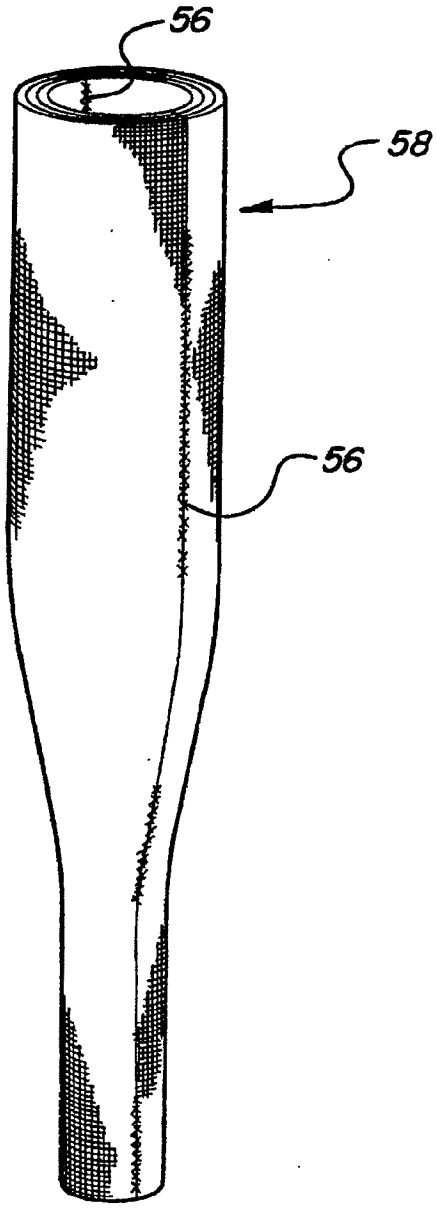


FIG-9

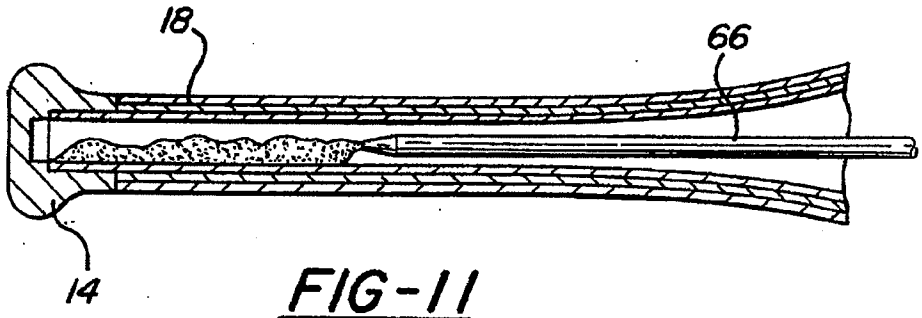


FIG-11

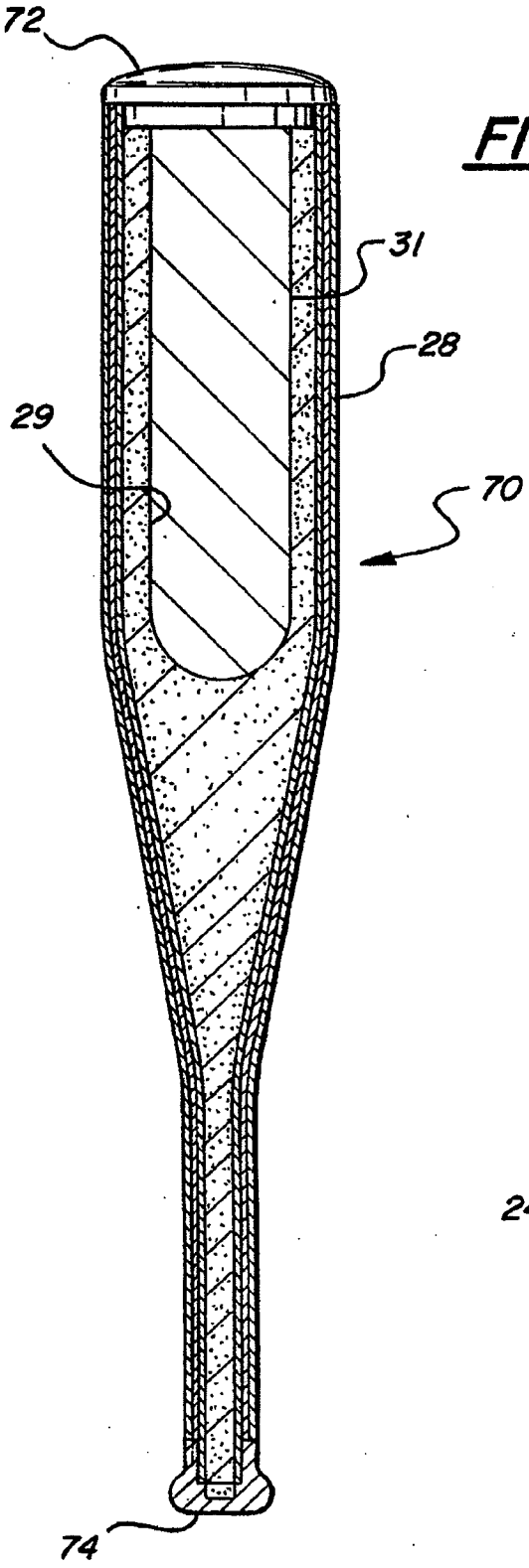
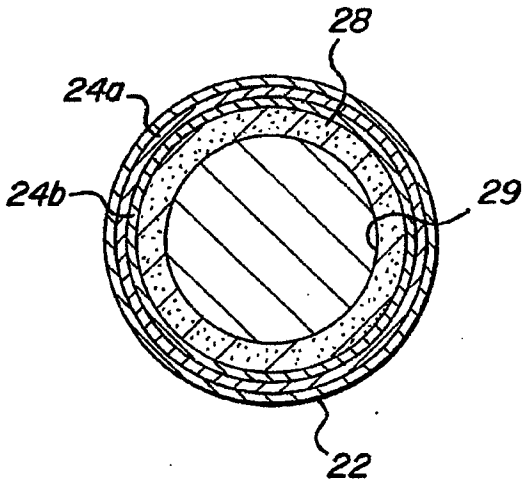


FIG-12

FIG-13



COMPOSITE BASEBALL BAT WITH CAVITIED CORE

RELATED APPLICATIONS

This application is a continuation-in-part of U.S. Ser. No. 137,694, filed Oct. 15, 1993 and presently pending, which is, in turn, a continuation-in-part of U.S. Ser. No. 883,263, abandoned, filed May 14, 1992, which is, in turn, a continuation-in-part of Ser. No. 518,782, filed May 4, 1990, and now U.S. Pat. No. 5,114,144.

FIELD OF THE INVENTION

This invention relates to baseball bats or the like comprising a cylindrical tube of wood veneer overlying a fiber reinforced resin layer and a central core, with the resin impregnating and bonding the three together, and to methods of forming such devices.

BACKGROUND OF THE INVENTION

My U.S. patent application Ser. No. 518,782 (now U.S. Pat. No. 5,114,144) discloses a baseball bat or the like formed of a tube halving an outer layer of wood veneer overlying an inner layer of fiber reinforced resin, with the two layers being impregnated with and bonded together with cured resin. Such bats have the desirable aesthetic appearance of solid wood bats, are much less susceptible to breakage in use than solid wood bats and can be designed to emulate the performance of either solid wood bats or exceed the performance of the livelier aluminum bats with larger sweet-spots. The present invention is directed toward improved versions of such bats and to methods of making the bats.

SUMMARY OF THE INVENTION

The present invention is directed to articles such as bats, drum sticks, billy clubs, cricket bats, field hockey sticks, furniture legs or the like, formed of cylindrical tubes. The preferred embodiment of the present invention takes the form of a baseball bat which tapers from a relatively narrow handle section into a larger diameter, bulbous, barrel section. The outer layer of the bat consists of one or more strips or sheets of wood or wood-like veneer. A single veneer sheet may be employed, in which case the grain of the sheet is preferably arrayed parallel to the longitudinal axis of the bat. If a plurality of veneer sheets are used their grains are preferably crossed relative to one another. Alternatively, strips of veneer may be wound around in spiral fashion to cover the bat.

In a preferred embodiment, the veneer layer is formed by cutting a pair of longitudinally extending sections of appropriately varying width, optionally imprinting at least one of the sections with a logo, and pre-shaping the sections the into semi-cylindrical configuration by soaking them with solvent and then shaping them in dies while a solvent is driven off by heat.

The veneer layer formed of these two preshaped sections overlies and is adhered to a tubular layer formed of multiple sheets of resin-reinforced, high tensile strength fiber fabric such as glass, carbon, ceramic or Kevlar®. The fiber orientations of the multiple layers are angled relative to one another. The fiber sheets may be knitted, woven or otherwise formed and are preferably formed as a tubular sock by edge seaming two longitudinally aligned sections. A pair of the

socks, with their seams displaced by 90° relative to one another are arrayed over a shaped form which may either constitute a mandril to be later removed or a permanent foam core for the bat. The fiber fabric is then coated with resin in liquid form, or preimpregnated fabric may be used, and the two veneer sections are positioned over the fabric. The resin is then cured while the veneer is pressed against the fiber layer either by means of a vacuum bag or matched dies. In one embodiment of the invention, employing a removal mandrel as a form, curing is accelerated by heating the formed composite at a suitable curing temperature for the resin. When the composite is formed ,over the foam plastic core, the curing temperature must be limited to prevent damage to the core.

After curing over a mandrel, the mandrel is removed, a preformed knob end is fitted over the open handle end of the tube, a preformed fiberglass cap is fitted over the barrel end, and both are adhered to the tube with resin. In one embodiment of the invention, a self-foaming plastic resin compound, preferably a urethane, is injected into the tube through a small hole in one of the bat ends. The two components of the resin react within the tube, filling the tube with a foamed core. The foamed in core may be partially hollowed out to form a core having a central cavity. The central cavity may be left hollow, or may be fitted with a second type of foam of a different (lower) density. Preferably, the volume of urethane components injected is varied along the length of the tube to create a higher density foam at the barrel end than at the handle end, shifting the center of gravity of the bat toward the barrel end.

Alternatively, the tube may be closed off at the handle end and the barrel end without filling it with foam to provide a hollow bat. When the resin impregnated outer tubes are cured directly over a foamed core, the handle end is fitted with a preformed knob and the barrel end with a preformed cap.

Alternatively, the core may be first molded in a suitable mold and covered with the fiber fabric sock and liquid resin prior to attachment of the veneer layer. The core may be formed with a molded-in (or otherwise formed, such as by hollowing out) central cavity, either empty or filed with a lower density material. Preferably, the central cavity radially extends from the longitudinal axis of the bat and extends longitudinally along at least a portion of the bat. The barrel of this embodiment of the bat may be made relatively larger with respect to the handle.

In the embodiments of the bat with foamed cores, the density of the foam is limited so that when the bat impacts a pitched ball, the tubular outer layers deform inwardly, locally compacting the core. The same localized deformation occurs with a hollow core bat formed in accordance with the present invention, but the hollow core bat also undergoes a larger hoop, radial distortion. The embodiment including the core with the central cavity undergoes a combination of local spring deformation and hoop, radial deformation. By adjusting the size of the central cavity, selecting the material of which the core is formed, and choosing whether or not to fill the central cavity with another material, the relative amounts of the two types of deformation may be changed, resulting in different performance characteristics. Thus, the bats of the present invention may be made to completely simulate the performance of a solid wood bat (which undergoes virtually no local deformation) or, alternatively, exceed the performance of the livelier aluminum bats with their larger sweet spots.

Other objectives, advantages and applications of the

present invention will be made apparent by the following description of several preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The description makes reference to the accompanying drawings in which:

FIG. **1** is a perspective, exploded, partially broken-away view of a bat, representing a preferred embodiment of the present invention;

FIG. **2** is a sectional view through the bat of FIG. **1** taken along line **2**—**2** of FIG. **1**;

FIG. **3** is a sectional view through an alternative embodiment of the bat having a hollow core;

FIG. **4** is a partial, longitudinal cross-sectional view through the knob end of the bat of FIGS. **1** and **2**, illustrating the knob end cap;

FIG. **5** is a partial longitudinal cross-sectional view through the barrel end of the bat of FIGS. **1** and **2** illustrating the barrel end;

FIG. **6** is a side view of a section of wood veneer, cut to form one of the two sections used to cover the outer surface of the bat of the preferred invention and imprinted with the logo required on the finished bat;

FIG. **7** is a perspective view of a veneer section after it has been preshaped for use in forming the bat of the present invention;

FIG. **8** is a view of multiple ply, knitted high tensile fiber fabric sheets cut to form a sock for use in forming the bat of the present invention;

FIG. **9** is a perspective view of a multi-ply, high tensile fiber fabric sock formed by sewing together two stacks of cut fabric sheets, for use in forming the bat of the present invention;

FIG. **10** is a sectional view through a resin-impregnated tube of wood veneer overlying a fiber sock, within the female dies used to form bats of the present invention;

FIG. **11** is a sectional view of a cured bat tube formed in accordance with the present invention, with a knob fitted at the handle end, in the process of having self-foaming, liquid resin components being injected into the tube to form a foam plastic core by a foam-in-place technique;

FIG. **12** is a sectional view through another embodiment of the bat having a core with a central cavity; and

FIG. **13** is a sectional view through the bat of FIG. **12** taken along lines **13**—**13** of FIG. **12**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present invention is not limited to baseball bats, and extends to similar articles such as drum sticks, billy clubs, cricket bats, field hockey sticks, furniture legs and the like, a bat constituting a preferred embodiment of the invention is illustrated in FIGS. **1** and **2**. The bat, generally indicated at **10** in exploded form, consists of a tube **12**, a handle knob generally indicated at **14** and a barrel cap generally indicated at **16**. The tube **12** has an outer configuration and dimensions like those of conventional prior art bats which are formed of solid wood, aluminum tubing, or fibre reinforced resin. The bat is radially symmetrical about a centerline, and tapers from a relatively narrow handle end **18** to a larger diameter, bulbous, barrel end **20**.

The outer surface of the bat is covered by a structural sheath of wood or wood-like veneer **22** coated and impregnated with a cured epoxy resin. The outer veneer sheath **22** covers the entire tube **12**. In a preferred embodiment of the invention the outer sheath **22** is formed of two longitudinally array strips or "planks" of white ash veneer of approximately ⅛ to 1/16 inch thickness. The term "plank" is used because the strips vary in width longitudinally so that when they are laid in side-by-side abutment with one another they form the outer contour of the bat without overlap. The strips are preferably laid with their grains extending longitudinally along the length of the bat to provide maximum longitudinal tensile strength and impact resistance. In alternative embodiments, each plank may be formed of a plurality of thinner sheets of wood veneer with their grains preferably arranged at angles to one another. In yet other embodiments, the sheath may be formed of thin strips of veneer which are spirally wound onto, or otherwise applied to, the bat.

The veneer outer surface **22** overlays a fabric layer of high tensile strength, resin impregnated, fabric socks *24a*, *24b*. Only two socks are shown for purpose of illustration although a greater or lesser number of sheets may be used in alternative embodiments of the invention. The fabric layer surrounds a core **28** formed of a resilient urethane foam, wood, aluminum, or the like. As will be subsequently described in detail, the core may vary in density over the length of the bat, preferably with a higher density section adjacent the barrel end **20** to shift the center of gravity of the bat toward the barrel end and improve the impact strength of the barrel.

The handle end of the bat, illustrated in detail in FIG. **4**, is closed off by the knob **14** which includes an extending cylindrical section **30** which is of the same outer diameter as the handle end **18** and abuts the termination of the wood veneer sheath **22**. The knob end **14** may be formed of plastic, solid wood or a combination thereof, and may be integral with the rest of the bat **10** by molding in a process which will be subsequently described.

Similarly, as illustrated in detail in FIG. **5**, the barrel end of the tube **20** is terminated by the cap **16**, preferably formed of fiber reinforced resin, which has a rounded end **32** and a tubular section **34** with an outer diameter which mates with the inner diameter of the fiber sections and is adhered thereto by resin. This end can also be formed in the mold with the bat.

Alternatively, the bat may be formed with a hollow core rather than a solid core **28**. A cross-sectional view of this alternative embodiment of the invention is illustrated in FIG. **3**, generally at **40**. The hollow core bat may otherwise be substantially identical to the solid core bat, although to achieve the same weighing, it is necessary to use heavier cloth socks *24a*,*24b*. A hollow aluminum core could also underlie the resin impregnated fabric layer.

One of the planks of wood veneer suitable in forming the bat of the present invention is illustrated in FIG. **6**. The veneer sheet **42** is cut from flat veneer stock by laser cutting, die cutting, router cutting, or like process so as to have the appropriate contour to cover half of a completed bat. The veneer section **42** includes a narrow, longitudinally extending handle section **44**, a relatively wide barrel covering section **46** and a tapered section **48**, joining the two. One of the two veneer sheets used to form the outer layer of the bat is preferably preprinted with a logo **50** while it is flat. The logo is preferably imprinted with an epoxy ink by a silk-screen process, or branded by burning.

Laser to cut sheet - NOT LOGO

In the production of the bat, the plank **42** is preshaped into a semi-cylindrical configuration to create a preform gener-

ally indicated at **52** in FIG. **7**. To achieve this preform shape, the plank **42** is saturated with a liquid solvent such as water, alcohol or the like, is then shaped into the semi-cylindrical form in either matched dies or one die using a vacuum bag to pressure the plank **42** against the die, and the plank is heated to drive off the solvent. This process stretches the cellulose fibers of the veneer to achieve the semi-cylindrical shape **52**. In alternative embodiments of the invention this preshaping step may be eliminated and the flat plank **42** may be shaped over the inner fabric layers as part of the same process that bonds the outer layer to the inner fabric.

The fabric socks **24** are preferably formed by stacking several sheets of fabric and cutting them into plank shape. A stack of three such "fabric planks" **54***a*,**54***b*,**54***c* are illustrated in FIG. **8**. Any number of sheets may be employed, but the preferred embodiment utilized stacks of four sheets. These fabric sheets may be woven or knitted or formed by other process, such as by filament winding or poultrusion over the core or mandrel.

By appropriate choice of the nature of the layers, the stiffness, strength, flexibility and elasticity of the final bat may be controlled. The preferred composition creates a bat with such properties that when the ball impacts the bat during the batter's swing the bat undergoes a localized deformation conforming to the contact area of the baseball, as well as radial or hoop deformation (the cylindrical bat temporarily deforms into an ovoid when viewed in cross section). It is important that foam core **28** be sufficiently resilient to allow this dual deformation which aids in the transfer of the kinetic energy of the swinging bat to the baseball. In the hollow core embodiment of the bat, illustrated in FIG. **3**, the outer tube of the bat also elastically deforms to produce oval distortion of the overall cylindrical configuration of the bat as well as the more localized deformation conforming to the contact area of the ball.

In the embodiment **70** of the present invention shown in FIGS. **12** and **13**, the core **28** is formed with a central cavity **29** which extends radially from the longitudinal axis of the bat and longitudinally along a portion of the length of the bat. The cavity **29** roughly underlies the "sweet spot" area of the bat. It has the effect of increasing the hoop spring and decreasing the local spring; i.e., bat **70** tends to deform more radially (into an oval) and less locally (thus producing the increased trampoline effect) than bat **10**. By adjusting the size and shape of the cavity **29**, bat **70** may be designed for maximum energy transfer to the ball it hits. Furthermore, the cavity **29** may be fitted or partially filled with a plug **31** formed of a different and generally less dense material to produce a composite core. Adjustment of the configuration of the cavity **29** also allows more effective matching of the veneer, fiber fabric and core density and resiliency.

The embodiment shown in FIGS. **12** and **13** may be made so that the barrel **72** is relatively larger than the handle **74** than is the case in conventional bats, without unduly increasing the weight of the bat. A bat of such design may be particularly useful in youth or training environments. Similar designs may also be employed in other products where balance and "natural feel" are important.

After two stacks of plank shaped fiber sheets of the type illustrated in FIG. **8** are created they are preferably sewn together along their longitudinal edges, preferably using a zig-zag seamer or a butt-seamer along two lines **56**, to form a cylindrical sock **24**, generally illustrated in FIG. **9**.

One alternate method of forming the bat, this sock **24** is arrayed over an appropriately shaped aluminum mandrel **60** which has been precoated with a mold release compound. A second sock is then arrayed over the first sock with its seams displaced by 90° relative to the seams of the first sock. Alternatively, the core may be pre-formed of foam or aluminum, and the socks directly arrayed over the pre-formed core, thus eliminating use of the mandrel.

In preferred embodiment of the present invention, the fabric sock which directly overlies the mandrel **60** employs inner layers formed of DuPont Kevlar®, or S-2 glass fiber and three overlying layers of graphite fiber. The Kevlar® layer is preferably aligned with its fibers parallel to the longitudinal axis of the bat. The first graphite layer has its fibers arrayed circumferentially, at 90° to the first layer, the third and fourth layers have their fibers arrayed at 45° to the fibers of the first two layers. The Kevlar® fabric is preferably K-49 type weighing 11.6 ozs. per square yard and is 2160 denier, 41 ends per inch. The three graphite layers are of type 6K-T300 weighing 5.5 ozs. per square yard and having 12.0 ends per inch. The four layers are preferably knitted together with a thin sheet of polyester film which is marked with the required plank pattern. These five layers are then cut together to form a plank.

A second sock is preferably formed of similar materials, but with a layer of fiber glass weighing 1 oz. per square foot, with its fibers arrayed circumferentially, overlying the outermost glass layer. The socks are sewn using Kevlar® K-49 thread with 12 needles per inch.

A pair of preshaped wood veneer planks **52** are then arrayed in matched female molds **62** and **64**. The interior surfaces of the veneer preforms **52** are preferably coated with the liquid epoxy. The exterior, convex surfaces of the preforms **52** may or may not be coated with epoxy before their insertion in the mold **62,64**. The fabric socks **24** are also thoroughly impregnated with the liquid resin, and the molds are then closed over the sock coated mandrel **60** or the pre-formed core, and the dies heated to thoroughly cure the resin. The resin used preferably has a curing temperature in the vicinity of 300° F. The preferred resin composition is Reichold 37127 epoxy. The resin may incorporate various additives such as natural rubber to improve the resiliency of the finished bat.

After the resin is cured, the assembly of the wood veneer preforms **52** and the sock **24** are removed from the molds **62,64**, and the mandrel **60**, if employed, is removed from the barrel end of the tube. To form a hollow core bat, this tubular section may be finished by capping the handle end with cap **14**, joining the two by epoxy resin, and finishing the barrel end by the cap **16**, similarly adhered to the tube by epoxy resin. Alternatively, the caps **14** and **16** may be formed in the two part, matched female molds **62,64** with the other components, the molds including forms for molding the knob cap **14** and the end cap **16**.

To form the embodiment of the bat with its foam core **28** shown in FIGS. **1** and **2**, the handle end of the bat may first be finished with the cap **14**, as illustrated in FIG. **11**, and the components of a self-foaming resin injected into the preform through a tube **66** inserted through a small central hole in the open barrel end cap **16** which is later closed. In this method, the core is preferably a self-foaming urethane. Sufficient resin is injected to achieve a core density which may be in the range of 10–30 pounds per cubic foot. The quantity of liquid resin injected along the length of the tube may be adjusted to achieve a varying density foam. Preferably, the density of the foam at the barrel end is relatively high compared to the density adjacent the handle end to achieve a desirable end weighting.

Alternatively, the bat may be formed by using a pre-

formed core of urethane foam, aluminum, or the like, formed in female split dies, instead of the mandrel **60**. For the embodiment shown in FIGS. **12** and **13**, the pre-forming dies or molds may be designed so that the cavity **29** will be molded into the core. As previously mentioned, it may be partially or entirely filled with a less dense material. The cavity may also be formed by hollowing out matching portions of two molded halves of the core so as to form a cavity when the halves are joined. A weight of a high density material such as lead, may be imbedded in the barrel end of the core **60** to modify the weight distribution. The socks **24** are arrayed over the preformed core and impregnated with liquid resin, and the veneer preforms **52** are laid over the outer surface of the socks **24**. The caps **14,16** are placed at the handle and barrel ends. The assembly is preferably cured in matched female molds. Alternatively, it could be cured in a vacuum bag placed within an autoclave. In this method of forming the bat, the curing temperatures for the resin can be limited to avoid damage to the foam core, limiting the strength of the finished bat and increasing the curing time.

Rather than forming the fabric layers in the form of socks which are placed over the mandrel, the fabric layers may be formed by filament winding techniques or by "pulltrusion" techniques known in the composite art.

Having thus described my invention, I claim:

1. A baseball bat comprising a tube having a cylindrical outer layer of veneer overlying a cylindrical resin reinforced fiber layer formed of a plurality of sheets of fiber fabric, the fiber layer overlying a core including a central cavity formed therein, the surface of the veneer overlying the fiber layer and each of said plurality of sheets of fiber fabric being impregnated with and adhered to one another with resin such that the veneer layer is bonded to the fiber layer with said resin.

2. The baseball bat of claim **1** wherein said central cavity radially extends from the longitudinal axis of the bat and longitudinally extends along at least a portion of the length of the bat.

3. The baseball bat of claim **2** where the central cavity is at least partially filled with a material of a different density than the density of the core.

4. A baseball bat comprising a tube tapering from a relatively small cross-sectional handle and to a relatively large cross-sectional barrel end, the tube consisting of a cylindrical outer layer of veneer overlying a cylindrical resin reinforced fiber layer formed of a plurality of sheets of fiber fabric and overlying a core disposed within said tube and .defining a cavity in a region of the bat underlying a sweet spot coninciding with a desired striking region on the surface thereof to provide improved local deformation and radial deformation of said bat upon impacting a baseball, said veneer layer and said fiber layer being impregnated with resin so as to bond said veneer layer to said fiber layer.

5. The baseball bat of claim **4** wherein the cavity extends from the barrel end of the tube for a distance along the length thereof.

6. The baseball bat of claim **4** where the central cavity is at least partially filled with a material of a different density than the density of the core.

7. The bat of claim **4** further comprising a resin reinforced fiber end cap disposed on the barrel end of said tube and adhered thereto by said resin.

8. The baseball bat of claim **4** wherein the bat is constructed such that, when a ball strikes the bat anywhere on its surface but said sweet spot, the bat produces a stinging sensation when said handle end is gripped by a user.

9. The bat of claim **4** wherein the core is formed of foam plastic.

10. The bat of claim **4** wherein the core is formed of aluminum.

11. The bat of claim **9** wherein said foam plastic core has a greater density at the barrel end thereof than at the handle end thereof.

12. That bat of claim **4** where said sheets of fiber fabric are each comprised of at least one inner glass fiber or Kevlar® layer and first, second and third outer layers of graphite fiber, said inner layer being disposed with its fibers aligned with a longitudinal axis of the bat, the first outer layer being aligned with its fibers arrayed circumferentially and normal to the fibers of the inner layer, the second and third outer layers being arrayed with their fibers at 45° with respect to the inner and first outer layers.

* * * * *

XI. RELATED PROCEEDINGS APPENDIX

None